seebyte

Operational Automatic Target Recognition (ATR)

Whitepaper

Contents

Image: L3 Oceanserver

Introduction

The use of unmanned maritime systems (UMS) have revolutionized many jobs at sea, improving operational efficiency, lowering costs and reducing risk to life.

UMS have been employed to great effect on mine countermeasures (MCM) and seabed mapping jobs, where unmanned underwater vehicles (UUVs) and unmanned surface vehicles (USVs) carrying sonar payloads systematically search the seabed and water volume.

Time reduction is an important driver within MCM, and has led to a push towards the use of squads of unmanned systems to achieve the mission faster. Autonomy software allows users to effectively deploy multiple UMS and gain the force multiplier effect. The data gathered also needs to be processed quickly, which is where automated analysis and target recognition technologies can help. This is commonly referred to as Automatic Target Recognition (ATR).

Sidescan sonars are used to collect seafloor imagery at high resolution. In order to survey the seafloor as quickly as possible the search patterns used produce a limited number of passes over each area, typically with only 1 or 2 observations available. Analysis of the sonar imagery is used to make critical decisions. Accurate analysis can lead to high probability of detection of mine like objects, with a low number of false alarms.

ATR technology provides analysis comparable to a highly-trained analyst in benign scenarios (e.g. flat seabed). In more complex scenarios ATR technology can help the analyst to focus on probable objects of interest. Trust and engagement issues can be addressed through the provision of ATR as a decision aid that reduces user error, and provides a more consistent output regardless of experience.

Image: Ben Shread

Problems

Problem 1: Data analysis is time consuming

Analysis of the sonar imagery is carried out as a dedicated Post-Mission Analysis (PMA) process by a highly-trained analyst. The PMA process is a time-consuming and tiring task that requires training, attention to detail and an understanding of acoustics.

In most cases the PMA process focuses on detecting mine-like objects and assessing the characteristics of a seabed. Typically, the manual data analysis process takes the same amount of time as the UMS data collection. This is because the analysis must be carried out systematically, with each image reviewed individually, and in sequence.

Complexity of the seabed terrain can have a significant impact on the PMA process. Complex terrains, such as rocky seabeds, require the analysts to scrutinize the sonar imagery in great detail, requiring a greater level of concentration over long periods. Regardless of experience, fatique can set in quickly resulting in loss of concentration and increased numbers of errors.

This approach does not take advantage of other contextual information. Information metrics such as risk or terrain complexity are not integrated into the review process to speed-up the data analysis by focusing on the highest-value areas.

Image: Copyright of Shaun Roster Images & Thales UK 2020

Two sources of inaccuracy are false alarms and missed objects.

Problem 2: Manual data analysis is inconsistent

The PMA produces a list of objects of interest for further investigation. This is then used to prioritise additional data gathering tasks that require assets and personnel allocation. Inaccuracies in this PMA data can have a significant impact on mission tempo and risk to life.

Two main sources of inaccuracies in the PMA data are false alarms and missed objects. False alarms need further inspection, increasing the mission timeline and driving effort away from real threats. Missed mine threats have the potential for far more catastrophic consequences.

Factors affecting manual analysis performance include; the quality and resolution of the sonar imagery, the complexity of the seabed terrain, and long mission durations where fatigue can set in.

Inexperienced analysts tend to be more risk adverse than their experienced counterparts, often calling more false alarms. Missed objects and inconsistencies in the data analysis can be linked to fatigue, loss of concentration, or the stress of carrying out the crucial PMA.

Two analysts with the same experience often provide similar, but not identical analysis results. The same analyst can also provide different outputs from the same data when working under different circumstances.

Additional training and support can help address these concerns, but highly-skilled analysts are in limited supply and the mission timelines can place people under significant pressure.

Image: RNLN

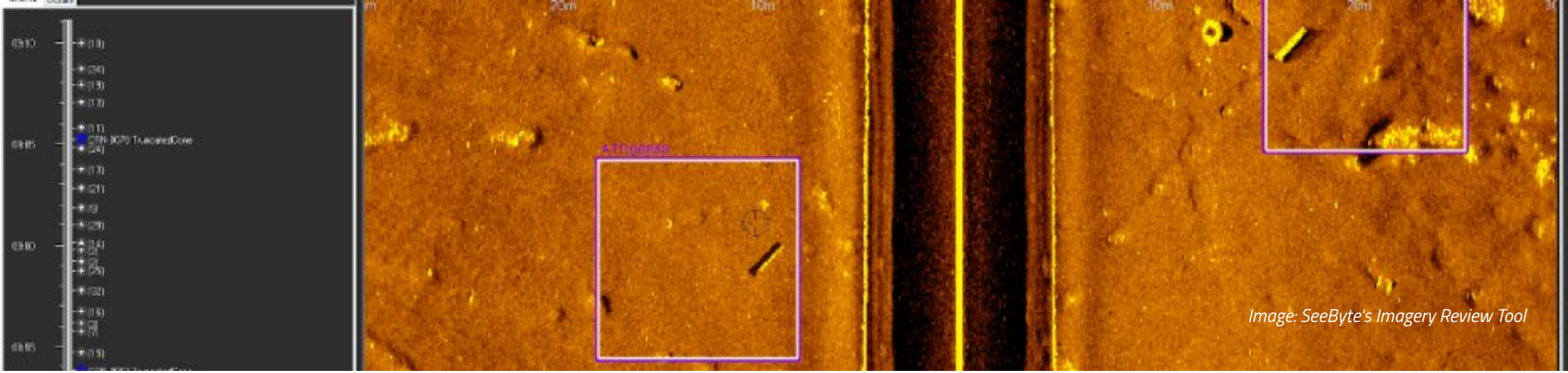


Image: SeeByte's Imagery Review Tool

ATR System

Technology has long played a key role in transforming MCM operations, reducing the workload burden on human users, and reducing the risk of having people in an active minefield.

ATR Systems now comprise of a suite of tools designed to operate as a decision-support system. Recent advances in Artificial Intelligence techniques, like Deep Learning, go well beyond the capabilities of most current ATR systems, and have the potential to revolutionise MCM capabilities. ATR Systems must now offer a combination of decision aid tools designed to support operator-guided workflows, where the analyst can choose to leverage the benefits of automated processing as and when appropriate.

Advanced ATR systems employ AI algorithms for terrain complexity analysis,seabed classification, and performance prediction, to further improve ATR performance and as a decision aid for the PMA analyst. Deep-learning algorithms can run up to twenty times faster than real-time, meaning that results are almost instantaneous. This provides a scalable solution as UMS squad sizes increase, and skilled personnel remain in short supply.

> *An ATR System is a set of tools designed to aid decision making. These tools support human-led workflows and offer improvements in both user performance and mission tempo. They help to address trust and engagement concerns that can hamper operational ATR usage.*

Solution 1: ATR is a performance equalizer

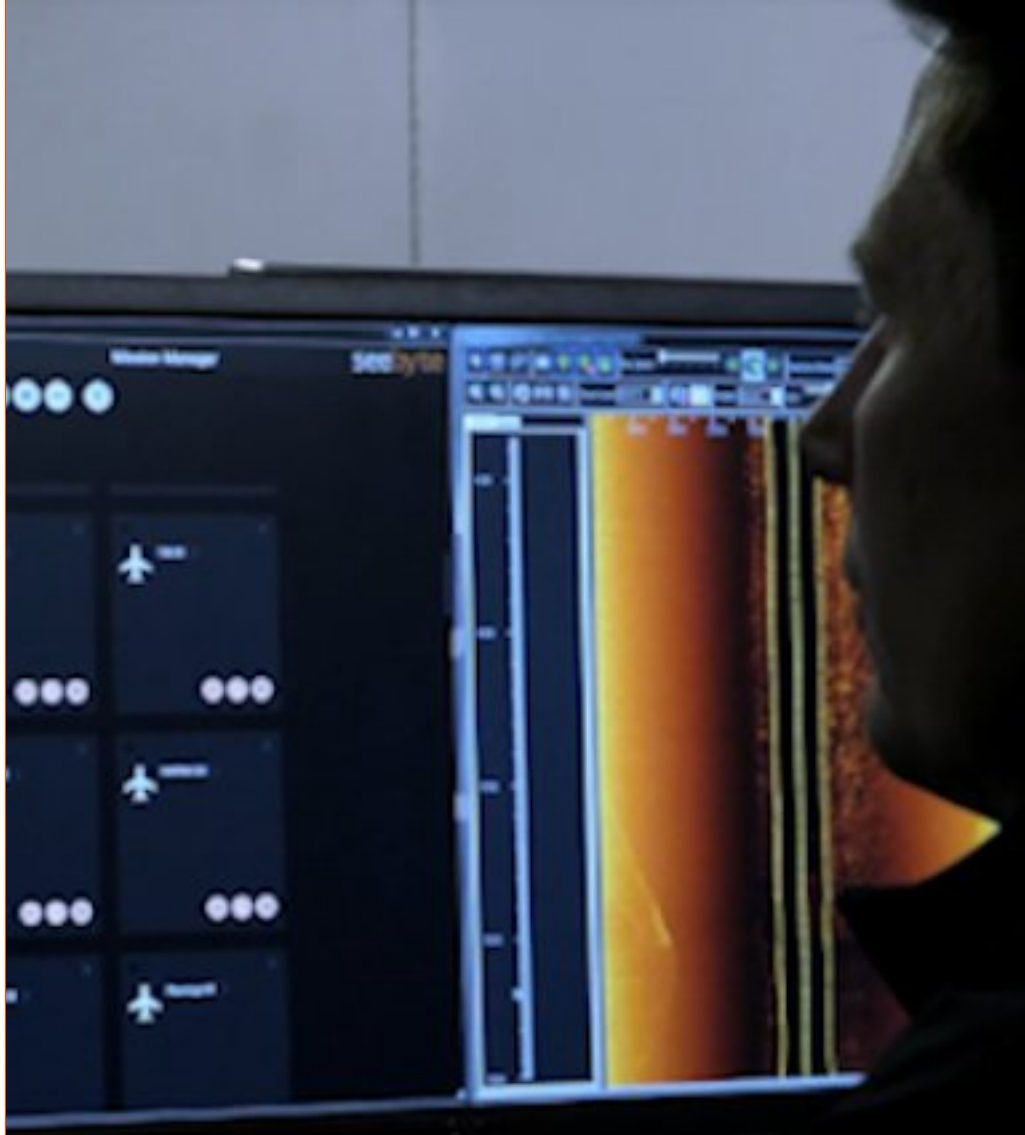
Automated analysis by the ATR System reduces variability in performance by providing the analyst with consistent recommendations. The ATR algorithms produce an identical analysis for a given dataset, allowing the analyst to focus on the high value decision making. This also helps less experienced analysts to reach the performance level of an experienced analyst.

Deep Learning Algorithms

The accuracy of ATR algorithms has improved significantly in recent years due to the adoption of deep learning technology. ATR algorithms can match the performance of an analyst on benign terrains for both Probability of Detection and False Alarm Rates. Trust has also been improved through workflows that offers ATR suggestions, in a non-intrusive manner, to support decision making.

The ATR System can also perform analysis on terrain complexity and estimate ATR performance across the survey area. This initial analysis can be used to determine the level of effort required for PMA and to prioritise data for review.

However, highly-trained human analysts remain in short supply, and increasing numbers of UMS with advanced sonars are generating large volumes of data for PMA. Using an ATR System can increase the baseline PMA performance and reduce variability due to human factors.



Choosing the right ATR system can dramatically improve PMA performance, with reduced variability and fewer errors.

Image: SeeByte's SeeTrack

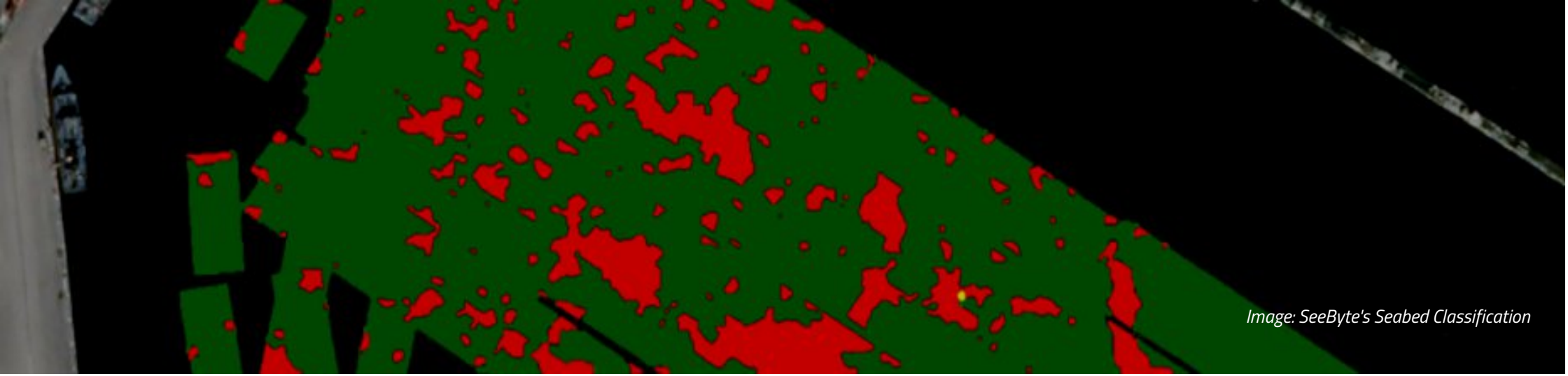


Image: SeeByte's Seabed Classification

Solution 2: Focus on the high-value areas

Automated data analysis algorithms provide results at a much faster speed than real time. Within minutes of the sonar data being downloaded, the automated data analysis can highlight different terrain types to the analyst. This capability provides new workflows for PMA based on the terrain type. The data can be classified into non-complex and complex terrain.

Benign terrain

On these terrain types, where the ATR performance is high, the analyst is able to focus on reviewing the ATR results. This provides the option to start reacquire missions almost immediately after finishing the initial survey.

Complex terrain

For complex terrain, the entire seabed will need reviewed, and the most experienced PMA analysts may be required. This decision can be made quickly using the automated tools provided by the ATR System, with PMA analysts starting work on the right data set immediately.

In-stride performance

In-stride performance estimation, that accurately estimates the likelihood of the ATR performing reliably in each area, can also be used. If confidence in the ATR results are sufficiently high for a given area then the task can be reduced to a single operation of accepting or rejecting ATR suggestions. This is particularly relevant in change detection scenarios, where the environment is well known and a list of previous contacts is available for comparison.

Repeat surveys

ATR Systems can bring further benefits for repeat surveys where the ability to identify changes in both the object and the environment is important. The task should be supported through visual comparison between the newly detected objects and previous observations held in the database. Changes can be identified and highlighted quickly, both individually and against terrain type.

> *Understanding the seabed terrain classification improves analysts performance and reduces PMA time.*

Image: Hydroid

Conclusion

The accuracy of ATR technology has improved significantly in recent years due to the adoption of deep learning technology.

ATR algorithms can match the performance of an analyst in all but the most complex terrains. ATR algorithms provide upfront suggestions allowing users to tailor the manual review process for their task.

User trust in automation technology is increased through ATR suggestions.

ATR aids non-experienced users and supports decisions made by expert users. PMA analysts are guided into a more accurate and consistent PMA approach when aided by ATR.

Users can perform PMA faster and reduce risk through suitable workflows.

Terrain analysis, and performance estimation tools provide flexible solutions that aid decision making. Analysts can use different workflows such as Ranked ATR contact review, Terrain-led review or Decision-aided waterfall review.

Significant time reduction is achieved through the use of ATR aided PMA.

Knowing where and when you can trust the ATR opens the possibility to avoid full manual review of all data. In some instances, such as repeat surveys in a known geographical area, the ATR algorithm can be further refined to allow change detection.

Integration of new ATR algorithms to leverage specialist knowledge.

The ATR toolbox solution must allow new ATR algorithms to be integrated, including third-party algorithms. The best combination of ATR algorithms can then be fused to provide optimal results.

Image: SeeByte's ATR System

What is the SeeByte ATR System?

The SeeByte ATR System is provided as an aid to assist decision making, and facilitate trust. The system allows the user to tailor the data analysis workflow to suit their operational requirements.

SeeByte's underlying ATR algorithm uses fast, supervised classification techniques based on a deep neural network. It provides a likelihood score for each detected object that allows the user to rank objects based on risk. Users that repeatedly operate in the same geographical area can benefit from enhanced ATR performance, using available data to refine the output of the ATR algorithm.

SeeByte's ATR Algorithm

Based on deep learning technology that achieves world-leading results in both Probability of Detection and False Alarm Rate. Automated contact measurements are also provided to aid decision making.

User Interfaces

Aid and expedite decision making with additional contextual information such as multi-pass views and dimension information.

Terrain Complexity

Characterising the seafloor terrain enables you to prioritise tasks and/or focus the data review process.

Third-Party Algorithms

Support for integration of third-party algorithms to leverage specialist knowledge, based on proprietary algorithms or classified data. The third-party algorithm is integrated as a black box, and does not need to be provided to SeeByte.

Automated Fusion

Automated fusion of objects for contact consolidation and grouping. Third-party algorithms can be run standalone, or in parallel to the SeeByte ATR algorithm to produce an improved fused ATR output.

For more information on our ATR System
visit our website