Boulder Detection & Measurement in Side Scan Sonar Data Using Deep Learning

by Coda Octopus Products, Inc.

INSIDE OUT

In many offshore infrastructure applications, conducting a pre-survey to analyze the seafloor for geohazards, such as boulders, is critical in determining an area's suitability for construction. Documenting boulders and understanding their distribution on the seabed is part of this analysis. Side scan sonar data collected as part of the pre-survey may be processed by trained personnel to identify the boulders on the seabed, marking their location and measuring their sizes. This manual process is very expensive and often suffers inconsistency when large datasets are handled by several processors.

Tagging boulders is a repetitive task and, therefore, can benefit from automation. In recent years, the explosive growth of neural networks has led to a rapid evolution in the field of automation. But how, you may ask? Well, unlike the regular software/logic written for a specific automation task, the neural networks can learn the ability to perform a particular task and improve progressively. A neural network is made up of a collection of nodes called neurons arranged in layers. Usually, neurons in one layer are connected to neurons in the next, creating a network of connections. Each neuron receives some signal, processes it, and sends it to the neurons nearby. Each connection between two neurons has a particular weight, a multiplying factor, associated with it and a signal passing through a connection would be multiplied by its weight, resulting in either amplification or dampening of the signal.

Imagine a simple Turing machine. To convert some input data into desired output, the dials on a Turing machine need to be tuned or configured in a certain way. The weights of a neural network are analogous to the dials of a Turing machine. They need to be tuned to transform the input information into expected output information. The tuning process is fairly automatic and is usually referred to as training. During training, the network gradually adjusts its weights based on the feedback of how close or far its output is from the expected. This powerful ability enables the neural networks to learn behaviours that are too complex to simulate using traditional logic and software.

But how do we train the network to detect boulders in side scan data? Side scan sonars emit acoustic signals and collect the backscatter from the seabed. These recordings can be represented as greyscale images with backscatter intensity as pixel values. In these images, boulders can be characterized as objects with high-amplitude return followed by a low-amplitude shadow. This representation makes it possible to leverage the advancements in object detection networks from the realm of deep learning, especially computer vision. These networks are specifically designed to detect objects in images and can be modified to automatically detect boulders on the seabed. One such adaptation is Coda Octopus' Survey Engine Automatic Object Detection Package (SEADP).
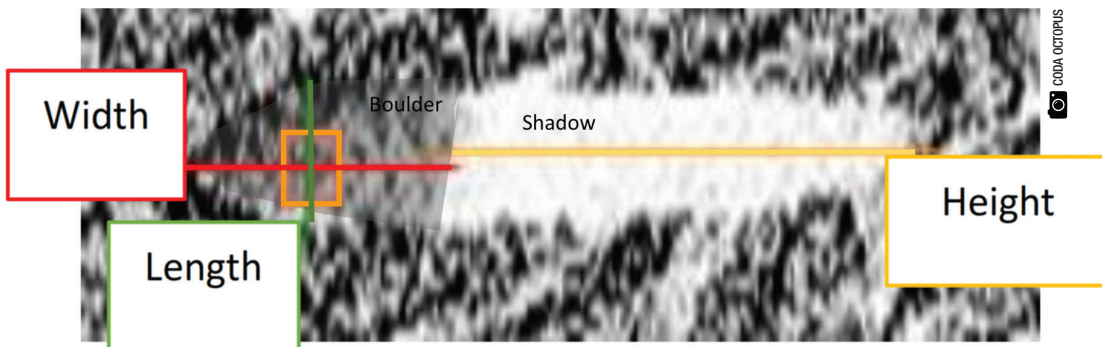
Figure 1A: Detected boulder with its measurement lines from Survey Engine Automatic Object Detection Package (SEADP).
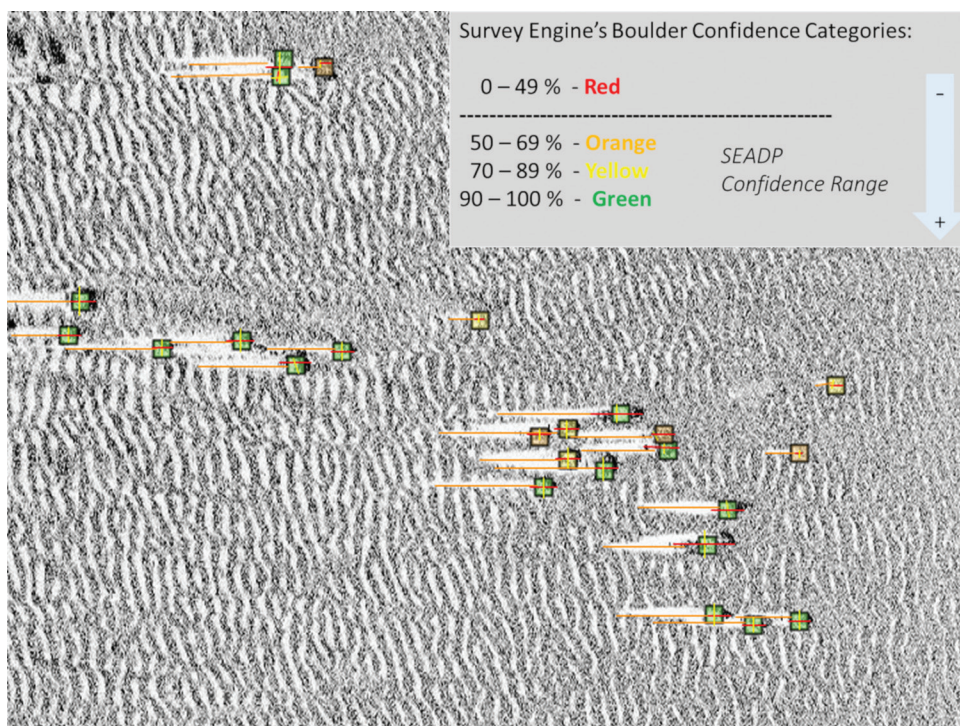

Figure 1B: Detected boulders on a side scan sonar channel with colour coding.

# Detected Boulders	Run Time h:m:s	Line Length (m)
5035	00:04:52	5182
1580	00:02:24	2883
128	00:00:31	462

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Figure 2: Survey Engine Automatic Object Detection Package (SEADP) benchmarking: number of detections, processing time, and survey line length in metres.

In our case, the network in SEADP is trained to take the side scan sonar images as input and report the regions containing boulders as output. SEADP can automatically detect boulders in the side scan sonar data and tag their geographic position in the surveyed area, including their size (length, width, and height; Figure 1A). For each identified target, it also reports an estimated confidence value that quantifies the likeliness of the target being a boulder. This confidence is visually indicated through the colour filled inside the tag (Figure 1B). Since the detection process is automated, tags will remain consistent across multiple survey lines.

SEADP is part of the Coda Octopus' Survey Engine ecosystem for processing, interpreting, and reporting of large datasets with a high level of precision and incremented productivity. Thus, automatically detected boulders can be comprehensively reported and edited in the same manner as any manual interpretation. Overall, SEADP gives a significant time and cost reduction in the task of tagging and reporting boulders (Figure 2). Various validation and benchmarking tests have shown that identification and interpretation of thousands of boulders can be reduced from days of work to only minutes with SEADP.