Deep Learning Techniques for Infrared Anti-Ship Missile Seekers

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Introduction

Modern imaging infrared missiles use sophisticated computer vision algorithms to detect and localise targets, however simulations have demonstrated that soft-kill countermeasures, such as flares, remain an effective defence against these systems [1].

Emerging deep learning techniques are the key to developing more robust imaging seeker systems. However, these algorithms require huge amounts of carefully labelled example data which, in the case of naval ship infrared imagery, is extremely limited.

Given this problem, we aimed to develop a training procedure to optimise deep neural networks for infrared anti-ship missile seekers in the absence of any real-world infrared data.

Computer Generated Models

We built ten CAD models of existing ships, and conducted simulations, to generate multiple thermal signatures for each model. This synthetic data was augmented and used to train our neural network. Figure 1 shows our model of the Sejong the Great-class destroyer of the Republic of Korea Navy.

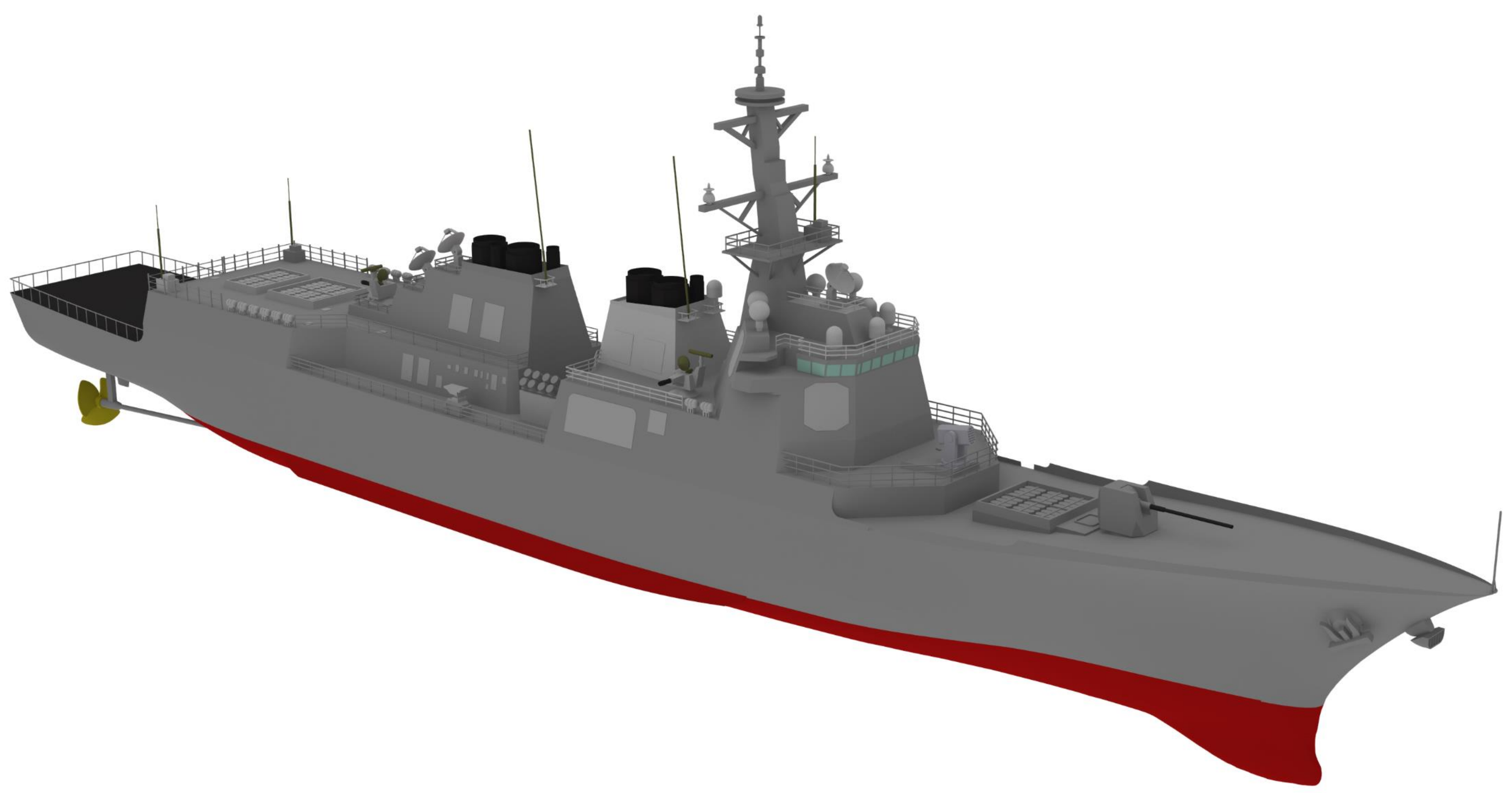

Figure 1: Sejong the Great-class destroyer of the Republic of Korea Navy

Neural Network

The neural network, illustrated in Figure 2, was based on the You Only Look Once (YOLO) fully-convolutional architecture. We used a 19-layer feature detector, resulting in a computationally efficient model that can perform detection and classification in real-time.

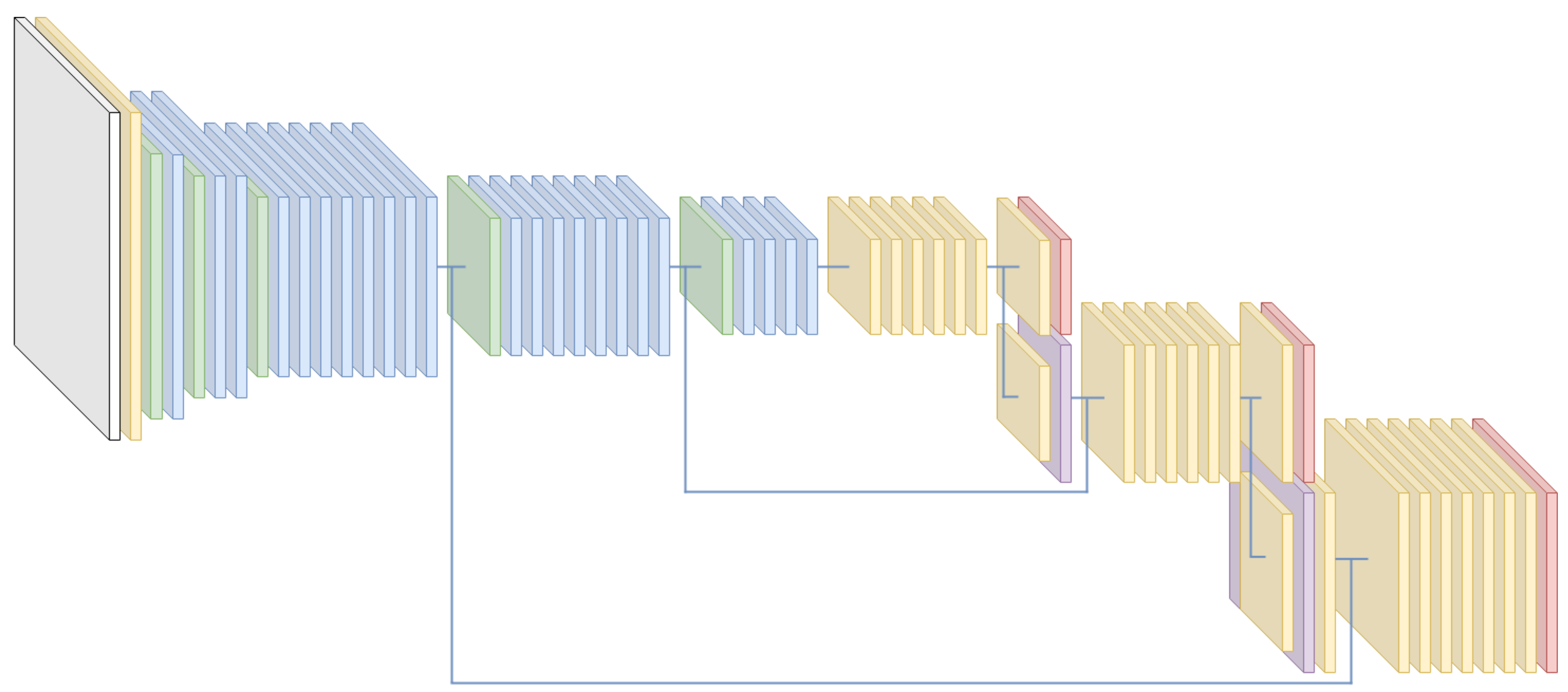

Figure 2: YOLO network architecture with a Darknet-19 feature detector

Results and Conclusion

The neural network was tested on both computer generated and real-world scenes, shown in Figures 3 and 4 respectively. In both cases, the network was able to consistently detect, recognise and identify all ships, even in the presence of background clutter and countermeasures.

This demonstrates the completion of our aim to optimize deep neural networks for deployment in the real-world despite the absence of any real-world data.

Figure 4: Algorithm performance on real-world data
(The ship has been pixelated and covered with a silhouette)

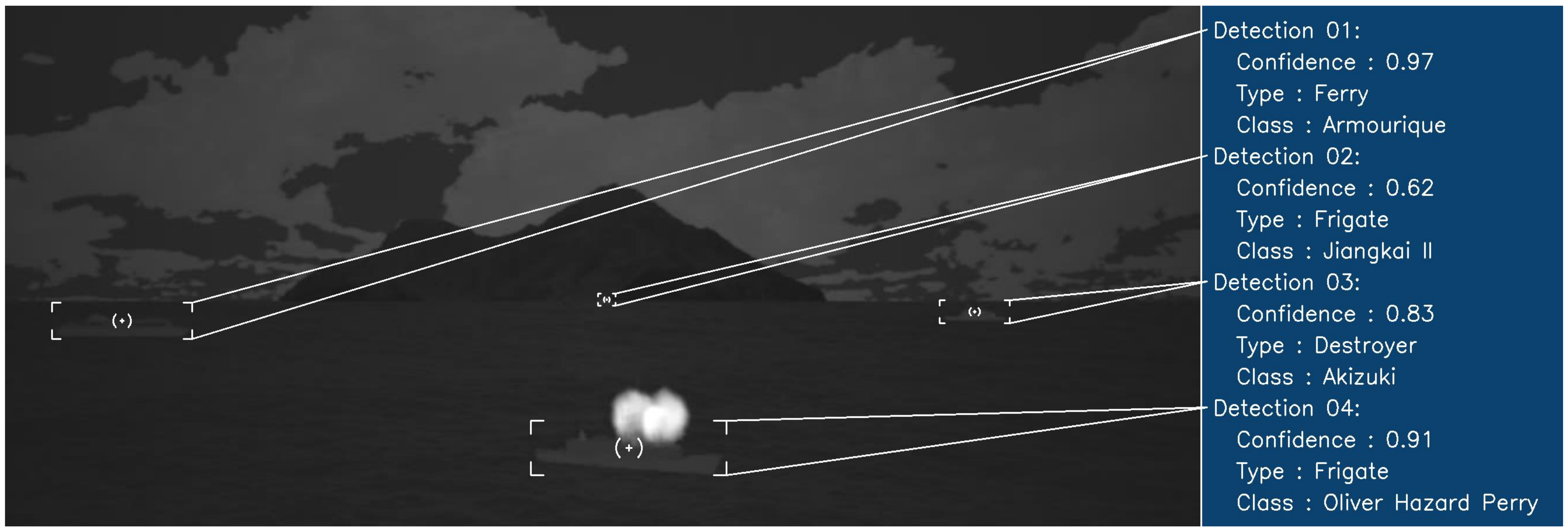

Figure 3: Algorithm performance for multiple targets at various ranges in the presence of background clutter and countermeasures

[1] Gray, G., J., Advanced Algorithms and Countermeasures for Imaging Infrared Anti-Ship Missiles, Cranfield University Thesis, 2013.