Machine Learning Engineer Nanodegree

Capstone Proposal

Arshad Burhan

Domain Background

Drifting icebergs present threats to navigation and activities in offshore areas. Currently, many institutions and companies use aerial reconnaissance and shore-based support to monitor environmental conditions and assess risks from icebergs. However, in remote areas with particularly harsh weather, these methods are not feasible, and the only viable monitoring option is via satellite. In order to keep offshore operations safe and efficient, we are going to investigate the fresh new prospective of how to use machine learning to more accurately detect and discriminate against threatening icebergs as early as possible.

Problem Statement

Statoil, an international energy company operating worldwide, has worked closely with companies like C-CORE. C-CORE have been using satellite data for over 30 years and have built a computer vision based surveillance system to keep the company’s offshore operations safe and efficient. The challenge is to build an algorithm that automatically identifies if a remotely sensed target is a ship or iceberg. Improvements made will help drive the costs down for maintaining safe working conditions.

Datasets and Inputs

In this challenge, you will predict whether an image contains a ship or an iceberg. The data is provided by the company. The data collection is briefly described here.
The remote sensing systems used to detect icebergs are housed on satellites over 600 kilometers above the Earth. The Sentinel-1 satellite constellation is used to monitor Land and Ocean. Orbiting 14 times a day, the satellite captures images of the Earth's surface at a given location, at a given instant in time. The C-Band radar operates at a frequency that "sees" through darkness, rain, cloud and even fog. Since it emits it's own energy source it can capture images day or night. Satellite radar works in much the same way as blips on a ship or aircraft radar. It bounces a signal off an object and records the echo, then that data is translated into an image. An object will appear as a bright spot because it reflects more radar energy than its surroundings, but strong echoes can come from anything solid - land, islands, sea ice, as well as icebergs and ships. The energy reflected back to the radar is referred to as backscatter.
When the radar detects an object, it can't tell an iceberg from a ship or any other solid object. The object needs to be analyzed for certain characteristics - shape, size and brightness - to find that out. The area surrounding the object, in this case ocean, can also be analyzed or modeled. Many things affect the backscatter of the ocean or background area. High winds will generate a brighter background. Conversely, low winds will generate a darker background. The Sentinel-1 satellite is a

side looking radar, which means it sees the image area at an angle (incidence angle). Generally, the ocean background will be darker at a higher incidence angle. You also need to consider the radar polarization, which is how the radar transmits and receives the energy. More advanced radars like Sentinel-1, can transmit and receive in the horizontal and vertical plane. Using this, you can get what is called a dual-polarization image.

Here, you will see data with two channels: HH (transmit/receive horizontally) and HV (transmit horizontally and receive vertically). This can play an important role in the object characteristics, since objects tend to reflect energy differently.

The labels are provided by human experts and geographic knowledge on the target. All the images are 75x75 images with two bands.

The data is presented in json format. The files consist of a list of images, and for each image, you can find the following fields:

- id - the id of the image
- band_1, band_2 – the flattened image data. Each band has 75x75 pixel values in the list, so the list has 5625 elements. Note that these values are not the normal non-negative integers in image files since they have physical meanings - these are float numbers with unit being dB. Band 1 and Band 2 are signals characterized by radar backscatter produced from different polarizations at a particular incidence angle. The polarizations correspond to HH (transmit/receive horizontally) and HV (transmit horizontally and receive vertically). More background on the satellite imagery can be found here.
- inc_angle - the incidence angle of which the image was taken. Note that this field has missing data marked as "na".
- is_iceberg - the target variable, set to 1 if it is an iceberg, and 0 if it is a ship.

Solution Statement

Since the problem is to differentiate between iceberg and ship images, we can train convolutional neural networks using the labelled images to capture the patterns and classify the images to ships and icebergs.

Benchmark model

A simple convolutional neural network is trained on band_1, band_2 features to classify the images into icebergs and ships, with an accuracy of 85%. I think the performance can still be improved using augmentation and somehow incorporating the incidence angle feature to the model.

Evaluation Metrics

The answers are evaluated on the log loss between the predicted values and the ground truth. The log loss metric for one instance is given by

$L = -(yt \log(yp) + (1 - yt) \log(1 - yp))$

where yt is the true value, ie ,1 for iceberg and 0 for ships

and, yp is the predicted probability that the image is an iceberg.

The aim is to reduce the sum of these values over all the predicted instances. Lesser the log loss, better is the model.

Project Design

Since Convolutional neural network is the promising model for image classification problems, my plan is to model the solution using the same. Few steps involved are-

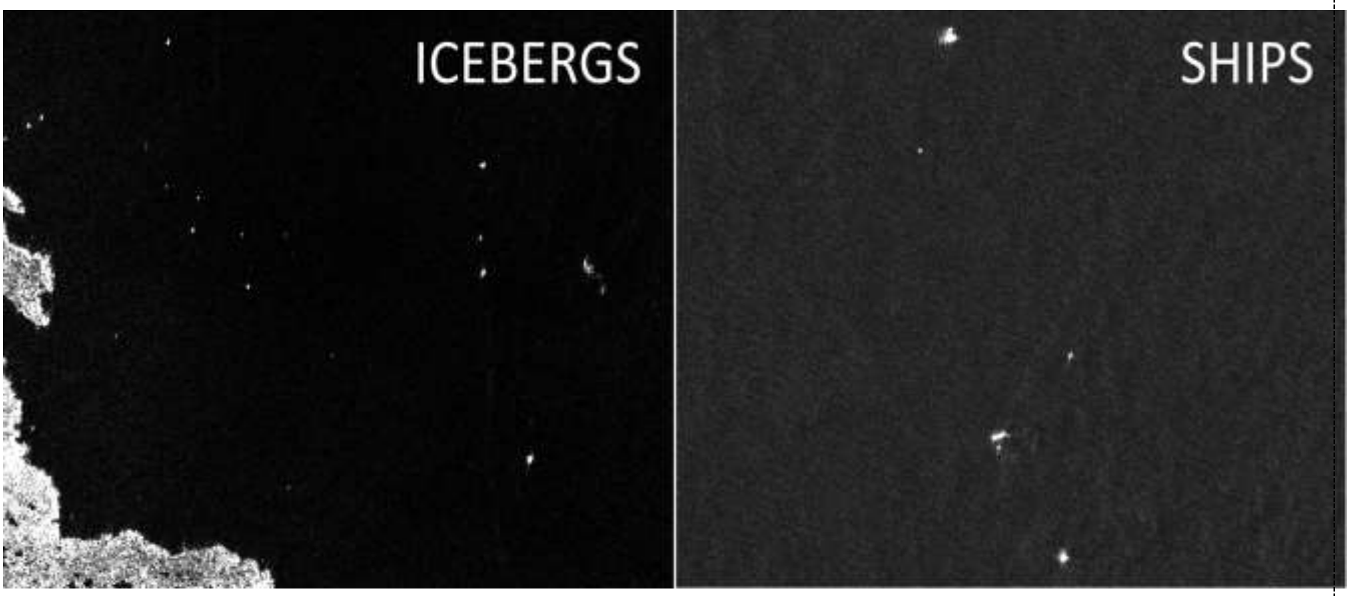
- Reshape the band_1, band_2 features to form two layers of the image of size 75 x 75.
- Train a convolutional neural network on those two layers to create a benchmark model.
- Create visualisations to better analyse what all things can be incorporated to the model which can improve the model performance
- Try using transfer learning from the state-of the art models, and maybe train some of the last layers.
- Try tuning the convolutional neural network hyperparameters like number of layers, nodes, learning rate etc…
- Try using various techniques like data augmentation, batch normalisation etc… and check what all methods help to improve performance.
- Find ways to incorporate the incidence angle feature to the model to improve performance.
- Find the best model through hyperparameter searching and fast iteration of models.

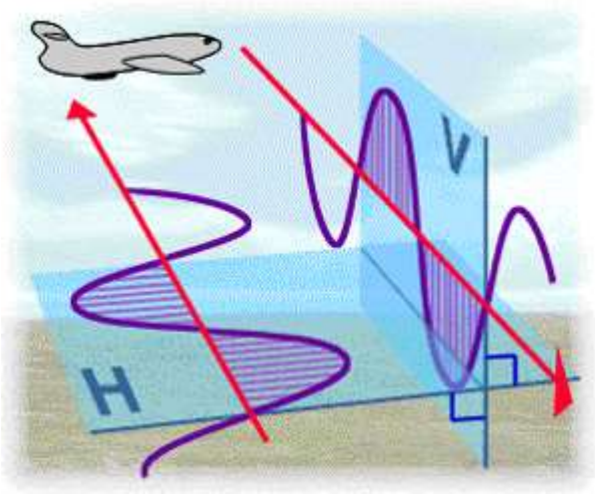
Finally, report the model that gives the least log loss error.

PS – It is a Kaggle competition.

Statoil, an international energy company operating worldwide, has worked closely with companies like C-CORE. C-CORE have been using satellite data for over 30 years and have built a computer vision based surveillance system

In this competition, you’re challenged to build an algorithm that automatically identifies if a remotely sensed target is a ship or iceberg. Improvements made will help drive the costs down for maintaining safe working conditions.





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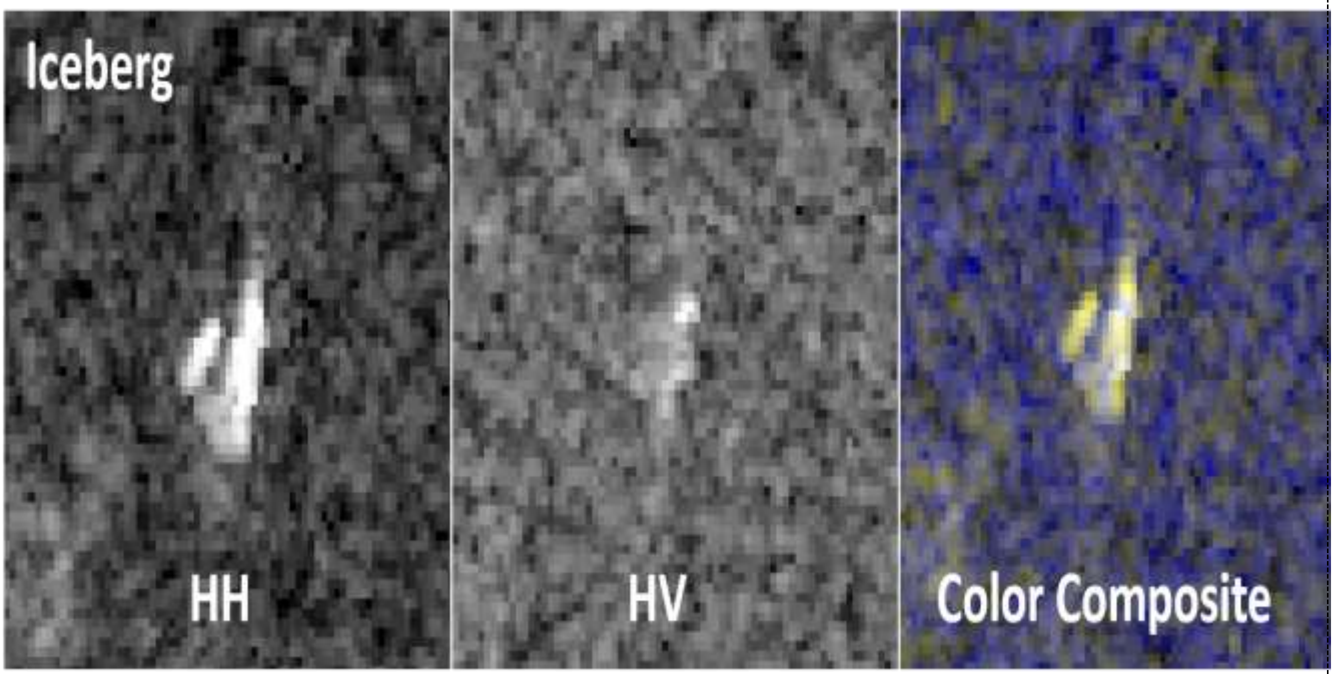
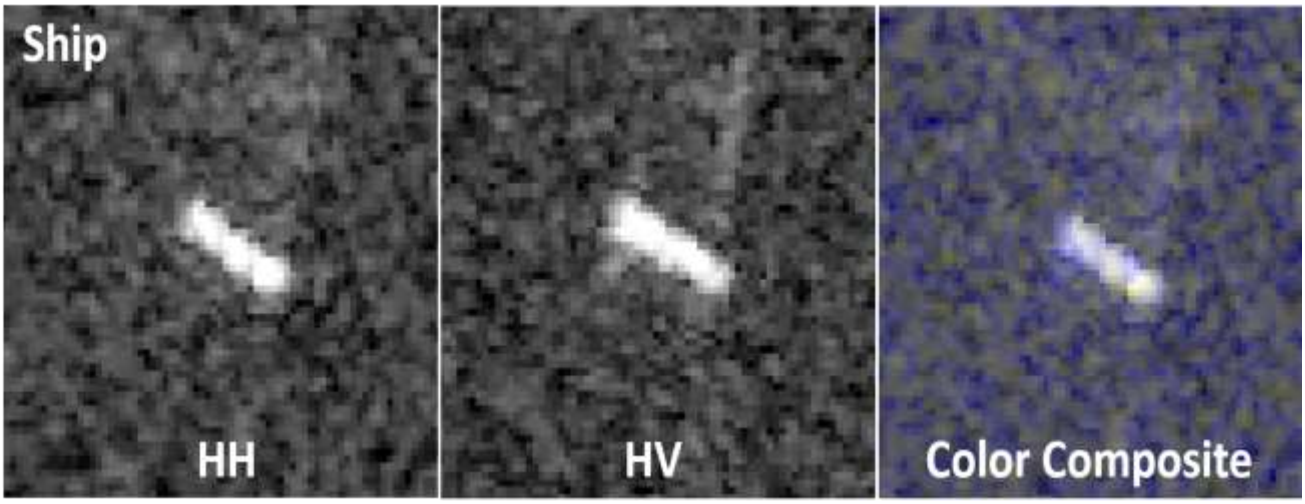
For this contest you will see data with two channels: HH (transmit/receive horizontally) and HV (transmit horizontally and receive vertically). This can play an important role in the object characteristics, since objects tend to reflect energy differently. Easy classification examples are see below. These objects can be visually classified. But in an image with hundreds of objects, this is very time consuming.





Here we see challenging objects to classify. We have given you the answer, but can you automate the answer to the question .... Is it a Ship or is it an
Iceberg?