

Detecting Ships in Satellite Images

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Predicting

Detecting ships location from the satellite images is a typical image target detection problem. Applications of this project such as searching ships on rescue airplanes, counting ships in a specific area, are of great value.

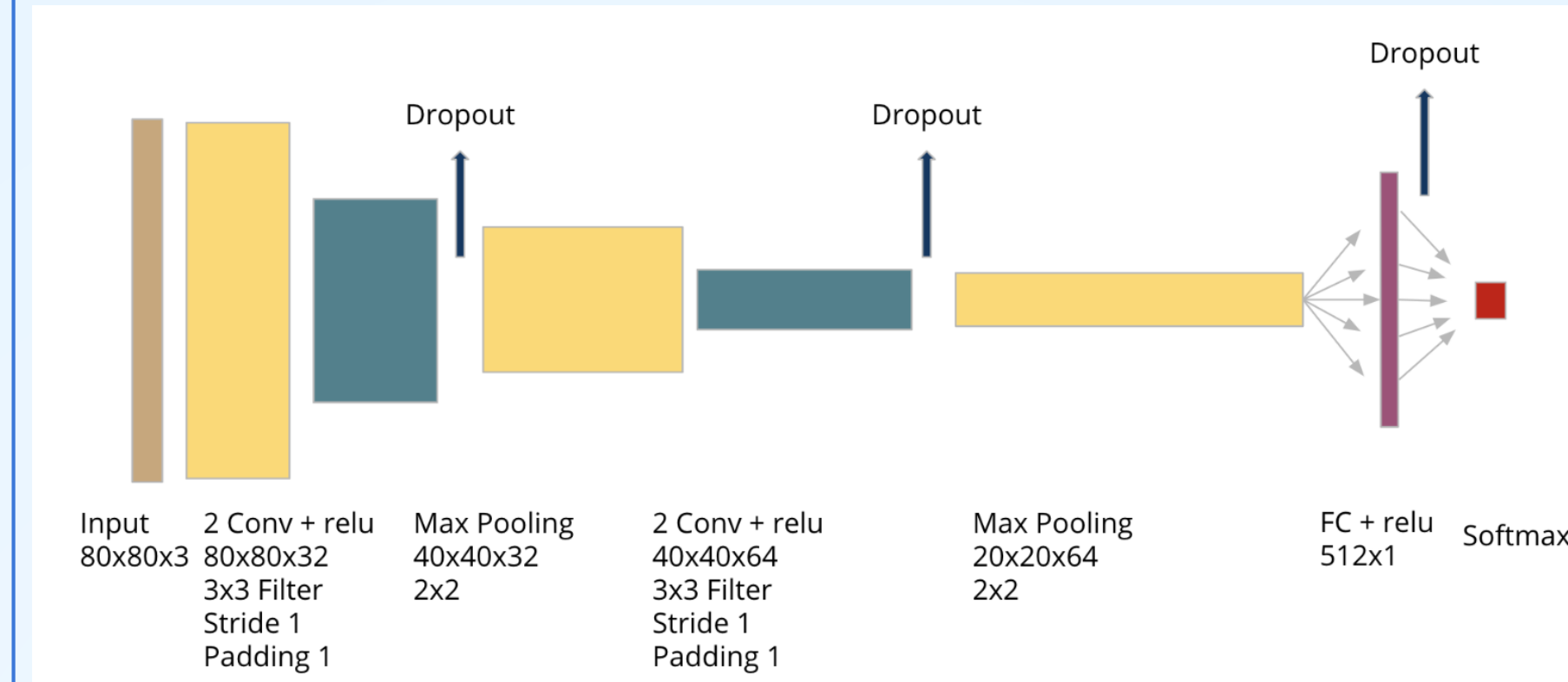
We use image classification to judge if a small image contains a ship, and use sliding window to propose regions in an image. Non-maximum suppression further combine close and overlapping bounding boxes. The desired result is an original satellite image with bounding boxes which locate all ships in the image.

Data & Features

The dataset^[1] we used consists of image chips extracted from Planet satellite imagery collected over the San Francisco Bay and San Pedro Bay areas. It includes 4000 80x80 RGB images labeled with either a "ship"(3000) or "no-ship"(1000).

We adopted data augmentation to expand training set to 8000 by rotating images. We divide the images into train set and evaluation set to measure performance and select the best algorithm.

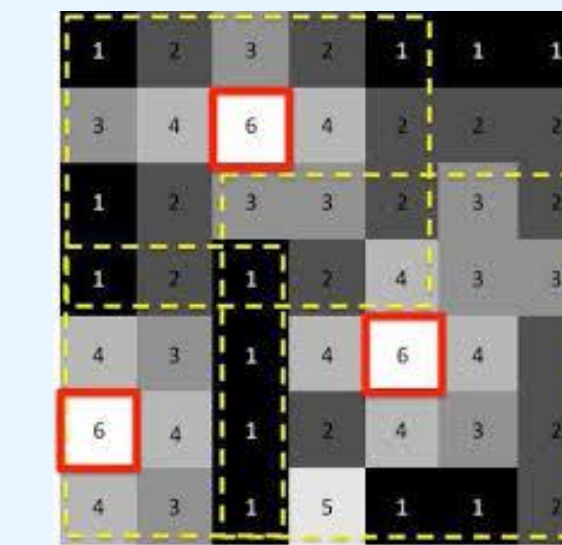
Convolutional Neural Network



Transfer Learning

We used the convolutional layers of either VGG-16 and ResNet as a backbone feature extractor, combined with a untrained FC layer at the end of network.

Non-maximum suppression



Pick detected centers with the biggest value within windows and delete other detected center within the windows to reduce redundant windows.

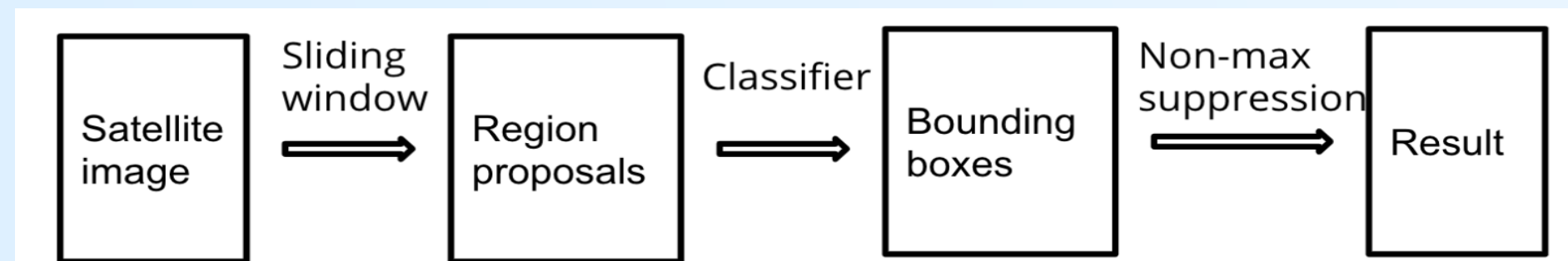
Discussion

From the results, when using the traditional machine learning algorithm, both XGBoost and GBC(Genetic Bee Colony) have good performance and have accuracy above 95 percent, the GNB (Gaussian Naive Bayes) has the worst performance on this classification problem. By using CNN, the accuracy is higher most of the traditional classifier.

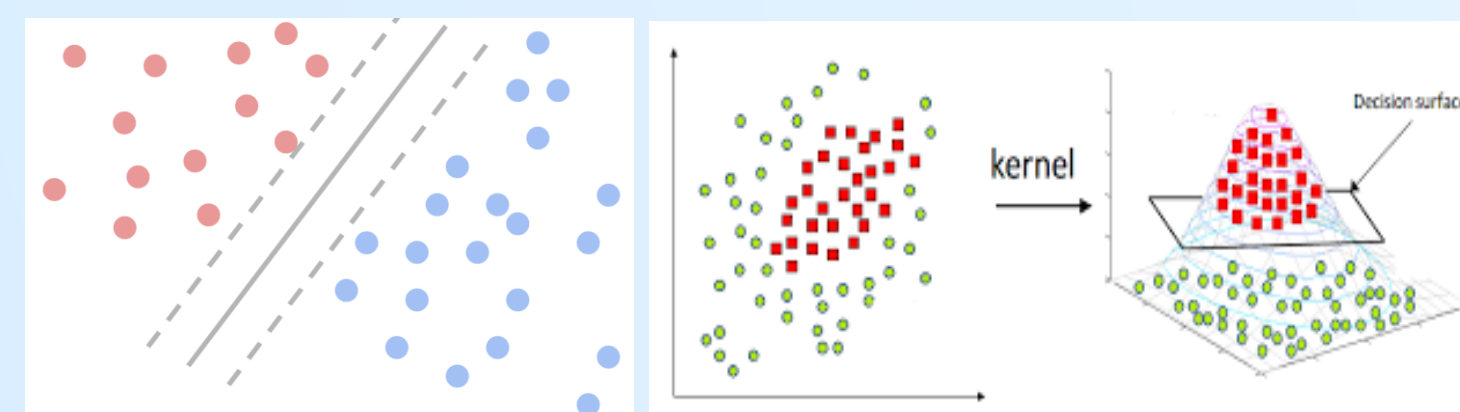
We used the method of the sliding window to do the find the target ships in the satellite images. From the result, it chooses to select some non-ship objects, such as the buildings on the land, which may be caused by the imbalance of ship images and non-ship images. Only 25% of images are non-ship images and the land images are even less. For the CNN model, it required hugh data to training, the accuracy of CNN will be improved if we have lager dataset.

Models

Workflow



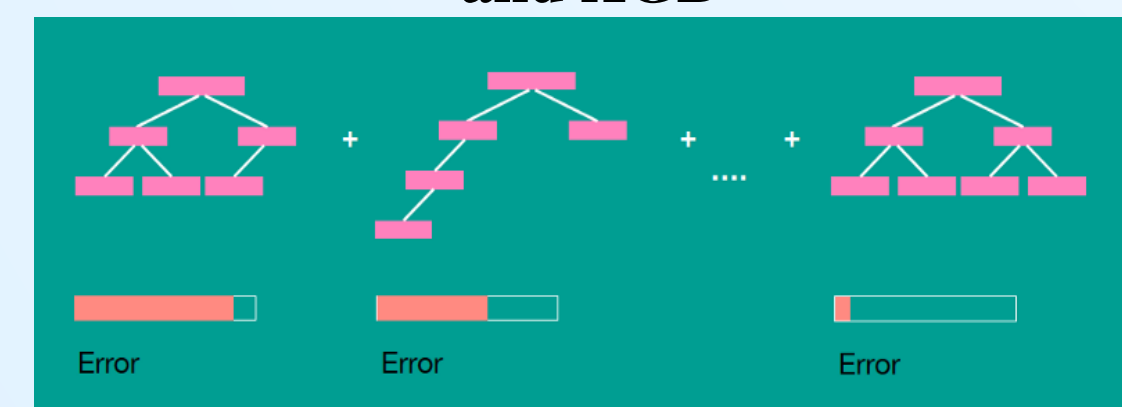
SVM



$$\mathcal{L}_D(\alpha) = \sum_i \alpha^i - \frac{1}{2} \sum_i \sum_j \alpha^i \alpha^j d^i d^j K(x^i, x^j)$$

Subject to $0 \leq \alpha_i \leq C$ and $\sum \alpha_i d_i = 0$

Decision Tree, Gradient Boosting Classifier, and XGB



Decision tree uses a tree-like model of decisions and their possible consequences, GBC is development of Decision Tree, and XGB is the improving of GBC.

Results

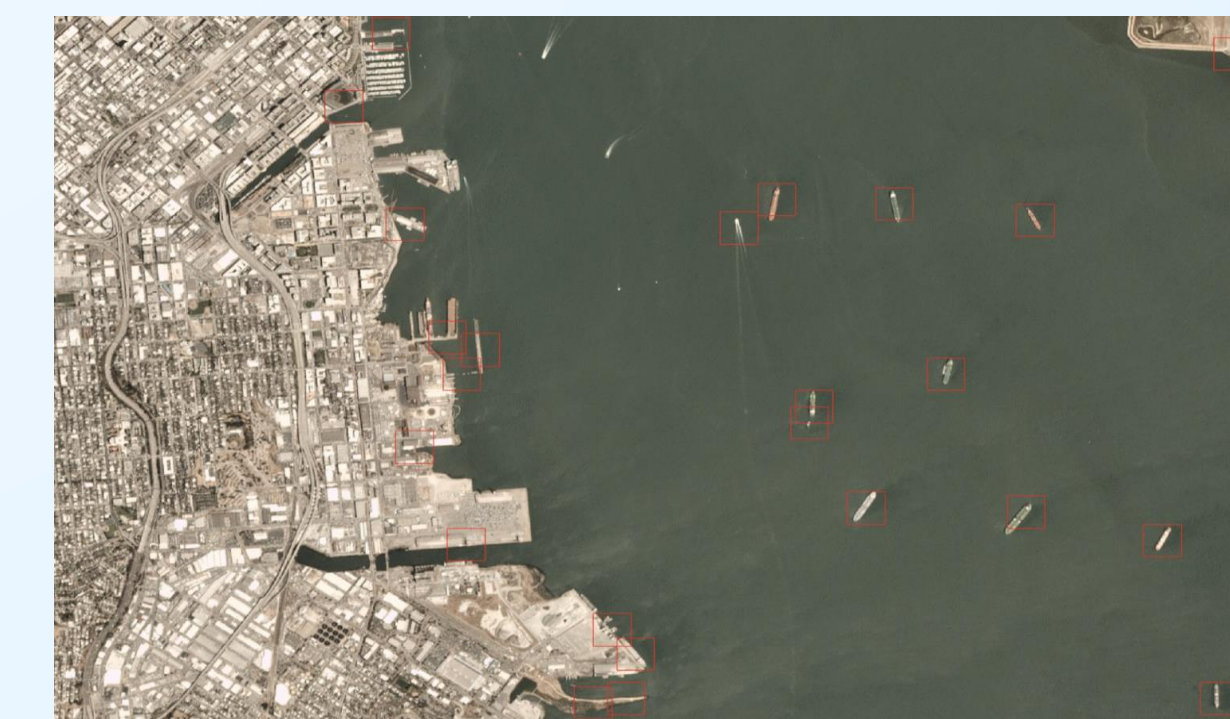
Classifier: Traditional ML methods and CNN result

XGB	GBC	RF	KNN	DTC	LR	LSVM	SVM	CNN	Transfer (VGG16)	Transfer (ResNet)
0.9572	0.9547	0.9444	0.9272	0.9009	0.8941	0.8906	0.7512	0.9375	0.902	0.915

Detecting ships of different sizes



Detecting ships using CNN



Although the ship classification accuracy of some classical ML method are higher, results of CNN are better than classical ML results in ship detection in the satellite images, this might because of that the CNN can learn better features by relating the neighboring pixels within a window.

Reference

1. Dataset: <https://www.kaggle.com/rhammell/ships-in-satellite-imagery>
2. M.Seetha, et al. "Artificial neural networks and other methods of image classification" (2017)
3. Carlo Tomasi "Histograms of Oriented Gradients" (2015)

Future

If we have more time on it, we would try some more efficient region proposal algorithms instead of sliding window. Also, we may try to find not only the location but also the cruising heading of the ship by analyzing HOG feature. A promising approach is to train an end-to-end model that directly outputs the result of both detection and classification (such as Yolo), but this requires training set with ship positions as groundtruth, which can be obtained from this project. Furthermore, ship path prediction is also a possible direction for use to development.