Ship Classification Using an Image Dataset

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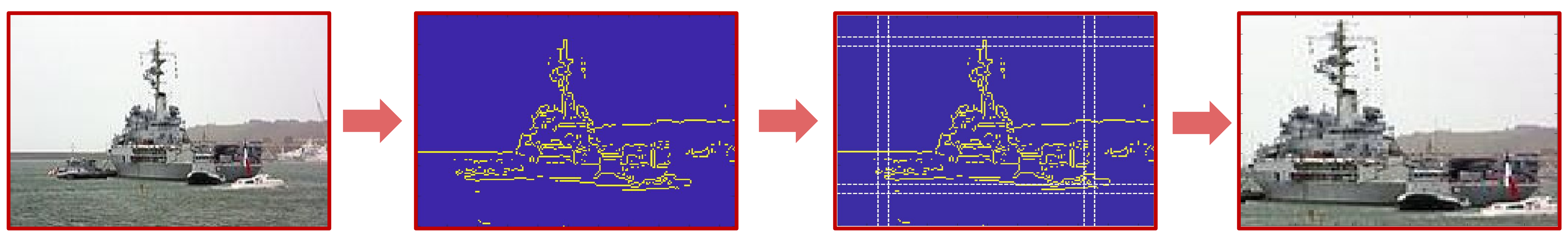
Introduction

The increased presence of autonomous systems requires reliable classification algorithms to understand their environment. These autonomous systems have the potential to find widespread use in sea and ocean waters, necessitating a reliable classification of ships in their surrounding. We are therefore interested in applying machine learning, and computer vision techniques to the problem of reliably classifying ships into different classes.

Image Preprocessing

Original → **Edge Detection** → **Jump Detection** → **Cropped**



Estimate row locations:
1. Integrate over rows
2. Detect maximum jump

$$r_x^* = \arg\max_{r_x} \left(\frac{\sum_{r=r_x-0.5r_{BW}}^{r_x+0.5r_{BW}} \sum_{c=1}^{c_{max}} |Image(r,c)|}{\sum_{r=r_x-1.5r_{BW}}^{r_x-0.5r_{BW}} \sum_{c=1}^{c_{max}} |Image(r,c)|} \right)$$

Row estimates (r_{min}, r_{max})

$$c_y^* = \arg\max_{c_y} \left(\frac{\sum_{r=r_{min}}^{r_{max}} \sum_{c=c_y-0.5c_{BW}}^{c_y+0.5c_{BW}} |Image(r,c)|}{\sum_{r=r_{min}}^{r_{max}} \sum_{c=c_y-1.5c_{BW}}^{c_y-0.5c_{BW}} |Image(r,c)|} \right)$$

Estimate column locations:
1. Integrate over columns
2. Detect maximum jump

Classification Methods

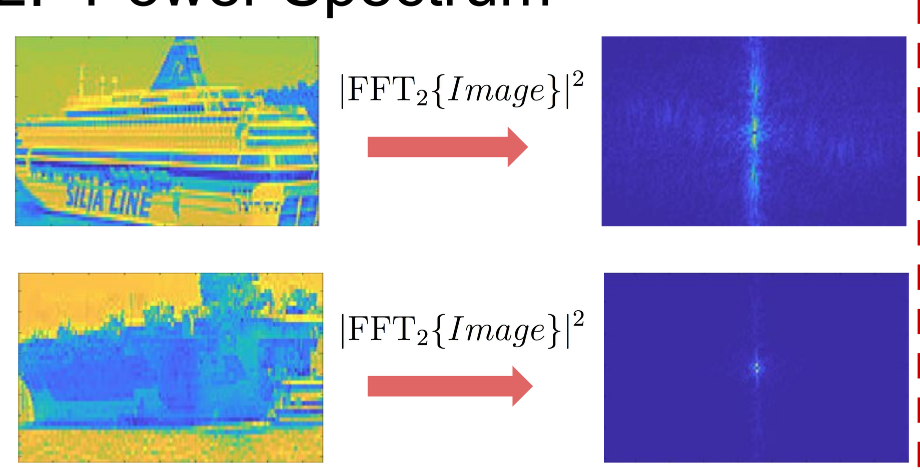
Bag of Features

- Extract keypoints; either by detecting features (using SURF) or dividing the image into grids.
- Obtain feature vectors via feature descriptors (SURF).
- Use K-means clustering to group features.
- Feed the projection of each image into SVM for classification.

Softmax Regression + SVM

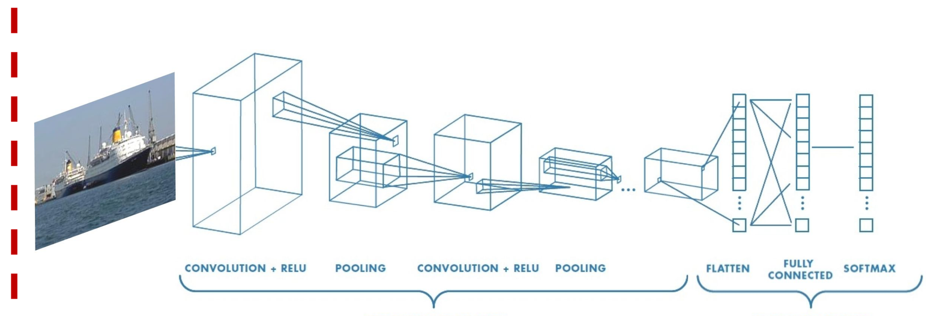
Preprocessing:
1. Extract ship from image
2. Normalize image size

Features:
1. RGB Color distributions
2. Power Spectrum



Convolutional Neural Network

- 25 layers
- Dropout layer and regularization used to reduce overfitting
- MATLAB neural network toolbox used



Data Collection & Dataset

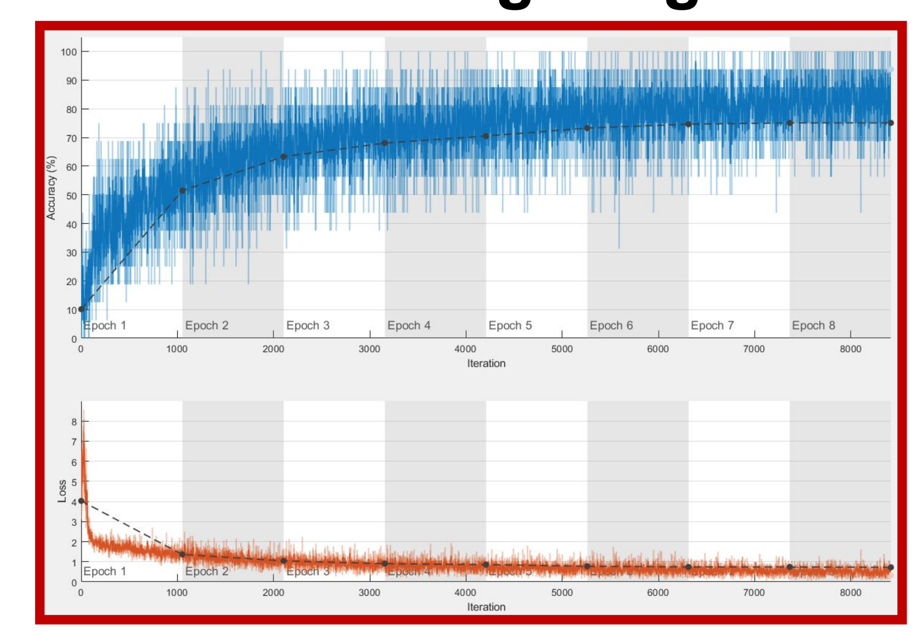
- Images were downloaded from a website [1].
- Images differ in size, quality, lighting, rotation, distance to the ship, and background.
- Dataset consists of 24052 different ship images distributed in 10 different classes.
- We divided the dataset into 3 subsets: Training, validation, and test sets with percentage division of 70-15-15, respectively.

Results

Accuracies of the Methods

	Training	Validation	Test
Bag of words	0.6900	0.4700	0.4800
Softmax regression + SVM (on 5 classes)	0.4098	0.3980	0.3980
Convolutional neural network	0.8803	0.7598	0.7633

CNN Training Progress



Discussion and Future Work

- CNNs outperform the other two methods as expected.
- The probability of correctly classifying restaurant/tour ships is the lowest. This is expected since restaurant/tour ships vary a lot, and do not have distinct physical characteristics.

Future work:
- Transfer learning using AlexNet, or some other pretrained network.
- Image preprocessing to detect multiple ships in an image, possibly belonging to different classes.

References

[1] Shipspotting.com, Home - ShipSpotting.com - Ship Photos and Ship Tracker, ShipSpotting.com. [Online]. Available: http://www.shipspotting.com/. [Accessed: 21-Oct-2017].
[2] E. Gundogdu, B. Solmaz, V. Ycesoy, and A. Koc, MARVEL: A LargeScale Image Dataset for Maritime Vessels, Computer Vision ACCV 2016 Lecture Notes in Computer Science, pp. 165180, 2017.
[3] C. Dance, J. Willamowski, L. Fan, C. Bray, and G. Csurka. Visual categorization with bags of keypoints. In ECCV International Workshop on Statistical Learning in Computer Vision., Prague, 2004.
[4] Mathworks.com. Available: https://www.mathworks.com/discovery/convolutional-neural-network.html.