Low Resolution Sonar ATR

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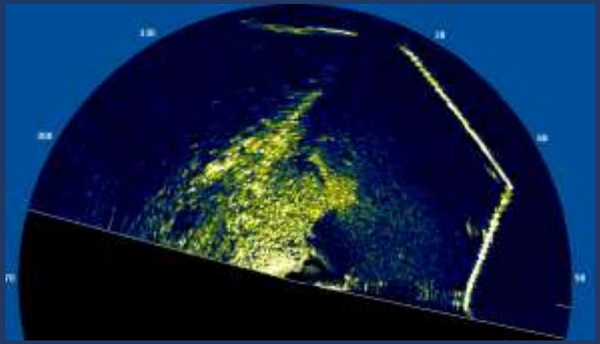
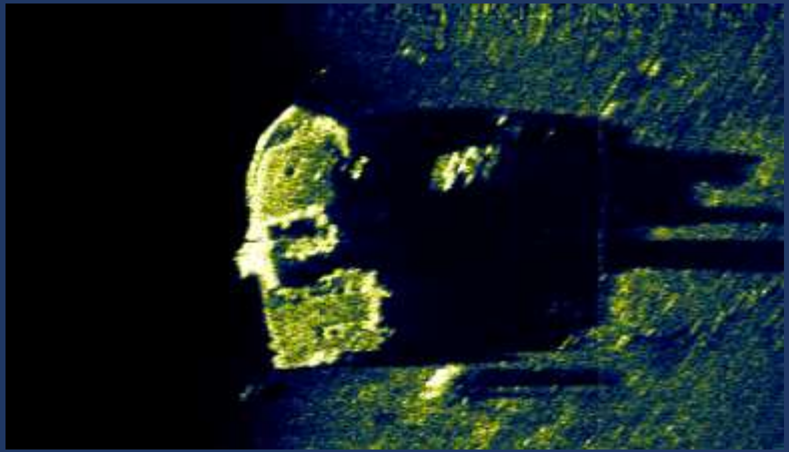
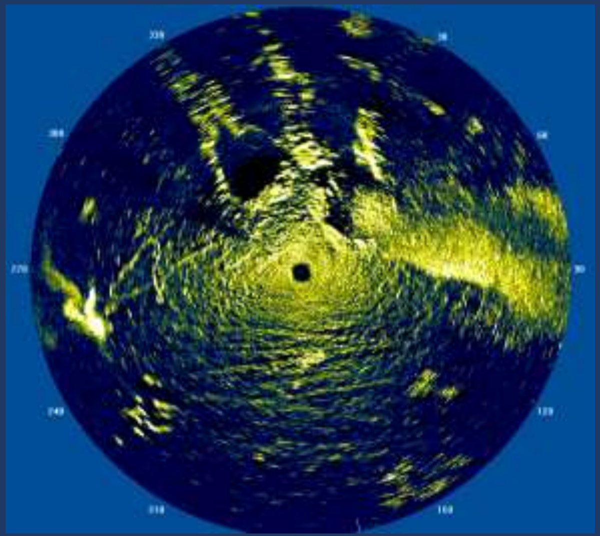
Project Introduction

- Sonavision SV1010
- Mechanical scanning vs SAS and Multibeam
- Exploratory nature of our project
- Role of The Data Lab







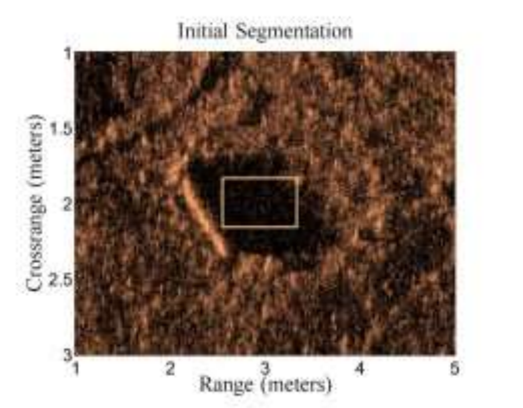
What is Sonar ATR?

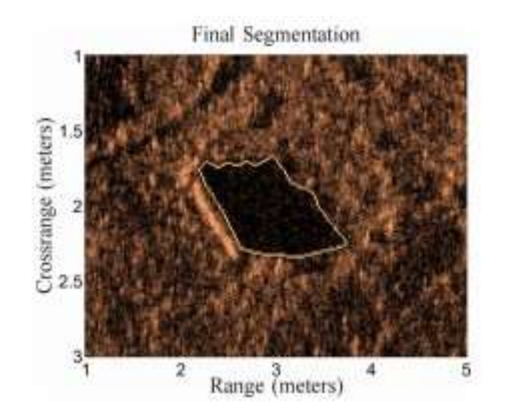
Motivation:
1. Teach a system expert knowledge
2. Sparse targets in data

There are three forms of ATR:
- Object Detection
- Object Verification
- Object Classification

Object Detection

Searching – target vs non-target
First stage in verification and classification problems.





Optimal Feature Set for Automatic Detection and Classification of Underwater Objects in SAS Images (Fandos & Zoubir, 2011)

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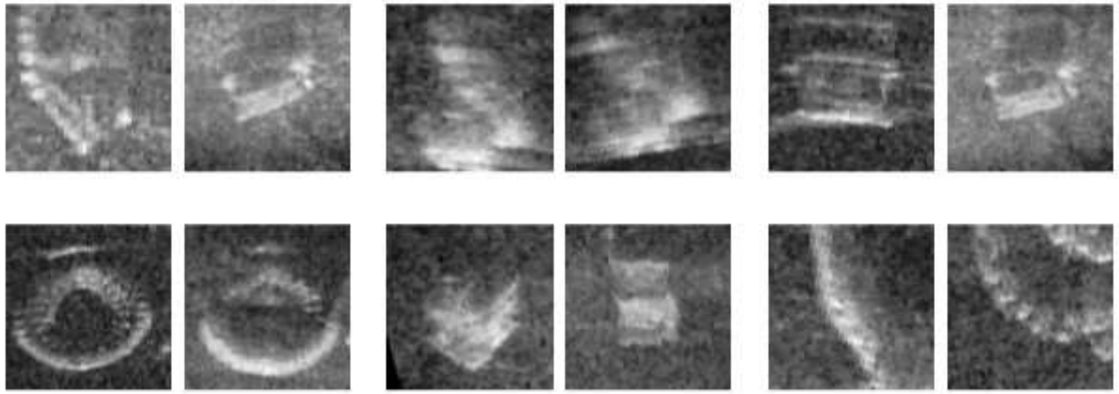
Object Verification

Template matching, but not concept matching.
For navigation, this means recognising an object it has seen before.



(a) Object-Object Matches

Improving Sonar Image Patch Matching via Deep Learning (Valdenegro-Toro, 2017)

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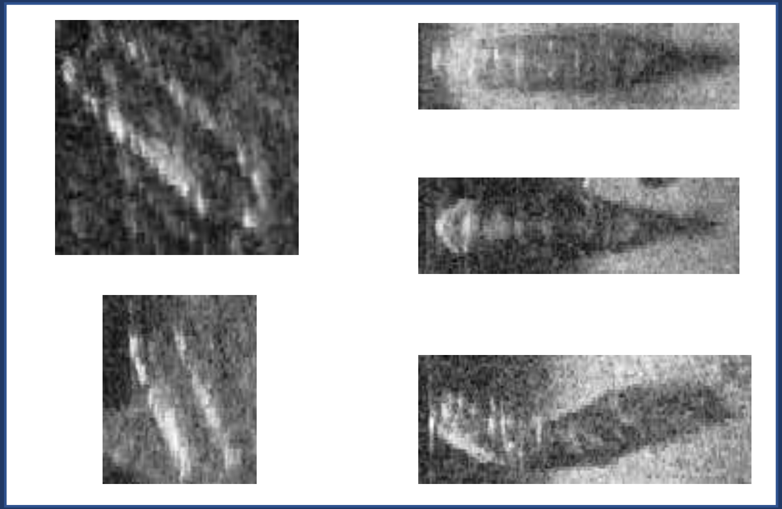
Object Classification

More general concept of the class of an object.



Best Practices in CNN for FLS Image Recognition (Valdenegro-Toro, 2017)

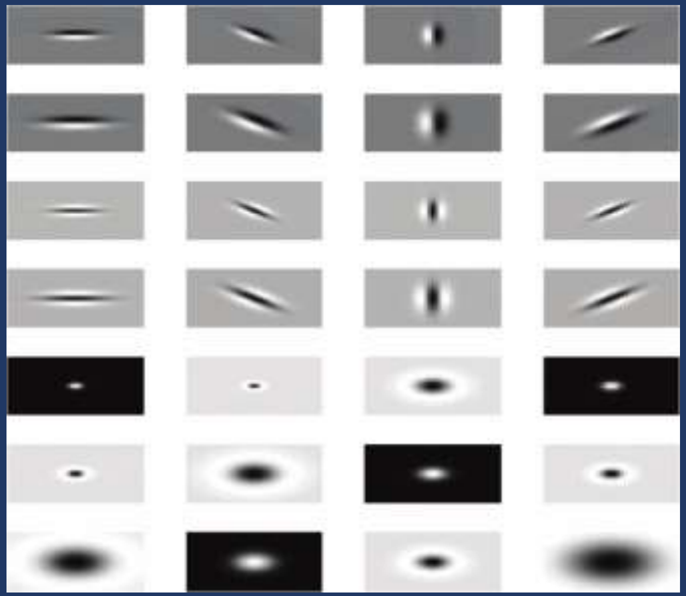
Previous work

Object detection:

Shadow detection – proud targets, sidescan.
CV techniques :
- SIFT
- HOG
- Haar cascades, Gabor and Gaussian filters

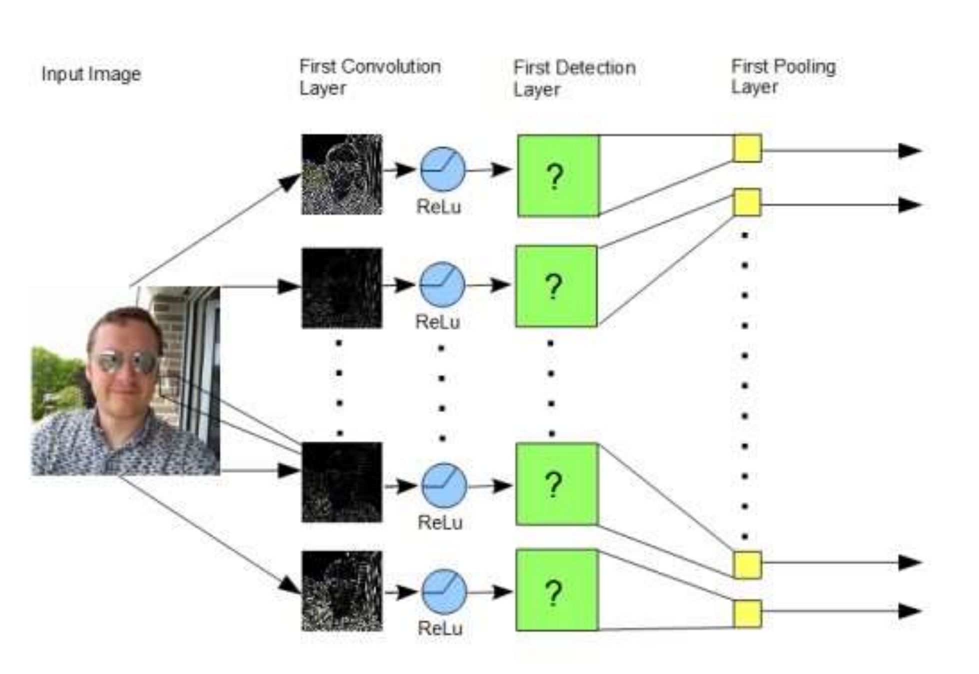
Limitations due to noise and variability of contrast.

Traditional CV methods have almost universally been replaced by Convolutional Neural Networks (CNNs) in most tasks.



Sonar automatic target recognition for underwater UXO remediation (Isaacs, 2015)

Convolutional Neural Networks (CNNs)



Three main ingredients:
- Convolutional filters
- Non-linear activations
- Local pooling

Convolutional Filters

- Detect features using response maps.
- Defined by size and sampling rules

Non-Linear activations

- Allow for more complex interactions between features.
- Decision-making role

Local Pooling

- Dimensionality reduction
- Functions may vary

Several people have used this before in the sonar domain, but there is much yet to explore.

Problems

- A lot of data is needed to learn a concept or to encode instances of the same object
- Ground truth for location or classes
- This requires either manipulating items in lab conditions and capturing images (unrealistic)
- ..or placing a variety of objects in underwater environment

If we don't have data, can we borrow it?

Transfer Learning

- Sonar concepts to new sonar concepts
- Sonar type to sonar type
- Synthetic sonar to real data

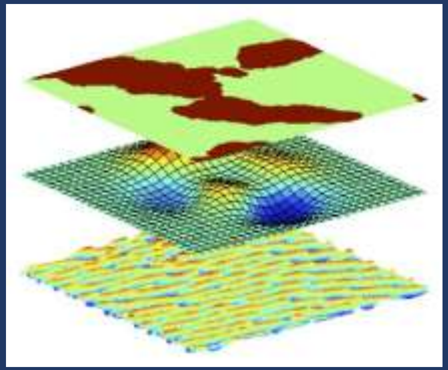
Using pre-trained networks

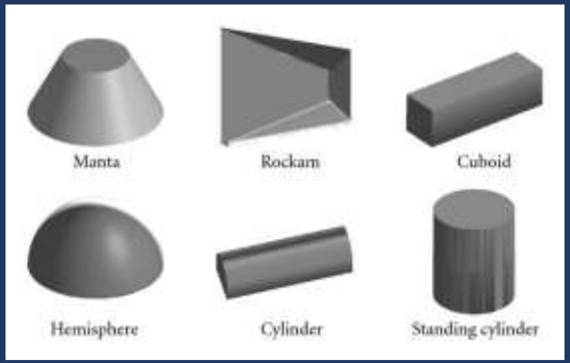
Synthetic Data

Physical realism vs image realism
Metric?

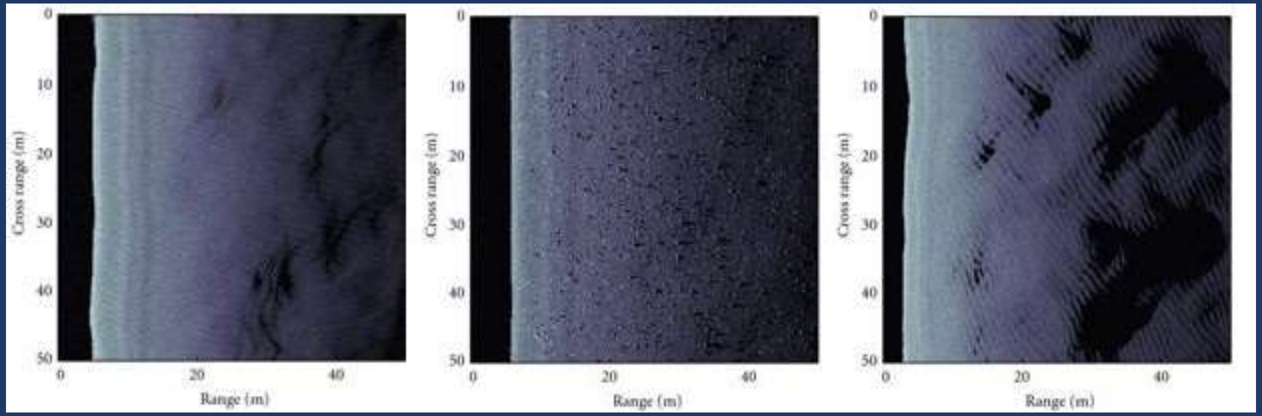
Imaging sonar simulation:
- Ray tracing
- Acoustic tubes
- Finite difference models
- Frequency domain modelling

Expensive to compute, but with the right tools…





High-Resolution Sonar (Pailhas, Petillot, Capus, 2010)



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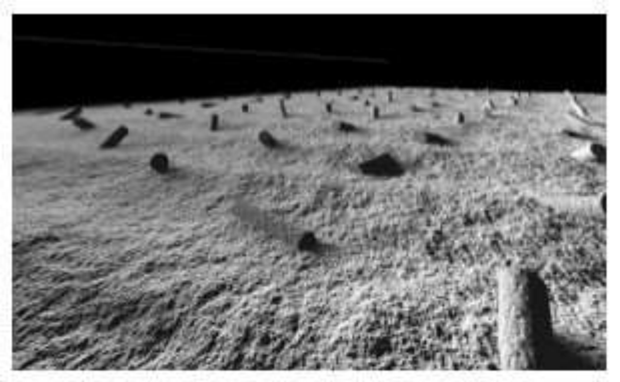
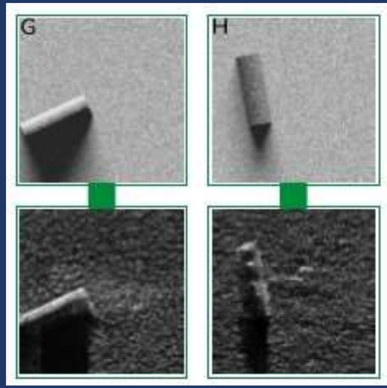
Expensive to compute, but with the right tools…
- Model-based transfer using style
- Generative based (GANs, VAE)

- Test set must always be real data

Deep Learning from Shallow Dives (Lee et al, 2018)





Coupling Rendering and Generative Adversarial Networks for Artificial SAS Image Generation (Reed et al, 2019)

Concluding remarks

- We want to use some of these techniques with the sonar device we have
- This might not be possible, but transfer learning may help.
- Data acquisition and generation is our current goal
- Build knowledge of sonar simulators and underwater acoustic modelling