Seabed Recognition Using Neural Networks

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Background

Sonar Imaging

- an advanced acoustic method to produce sea bed pictures.

Usage

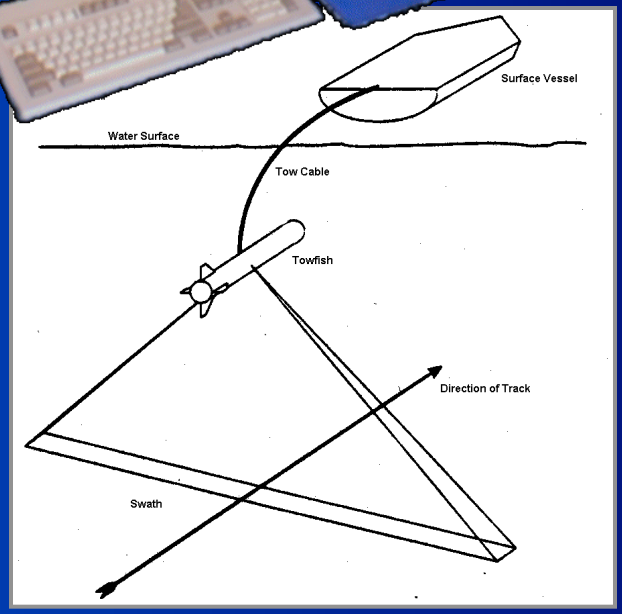
- Locating ship wrecks, drowned victims, missing objects
- Fish finding
- Seabed classification
- Military mine hunting

Side Scan Sonar System

Side Scan Sonar

- transmits an acoustic beam towards sea bed

- acoustic reflections are recorded as a sonar image



Objectives

Produce a map showing the seabed surface character

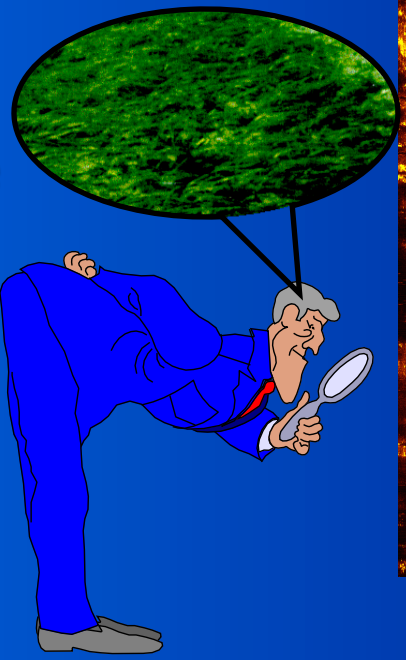
- MIKE 21/MIKE 3
  - Mud Transport (MT)
  - Sand Transport (ST)
  - Eutrophication (EU)
  - Hydrodynamic module (HD)
- GENIUS
  - Monitor dredging operations
  - Combine instruments to establish a near-surface seabed classification system

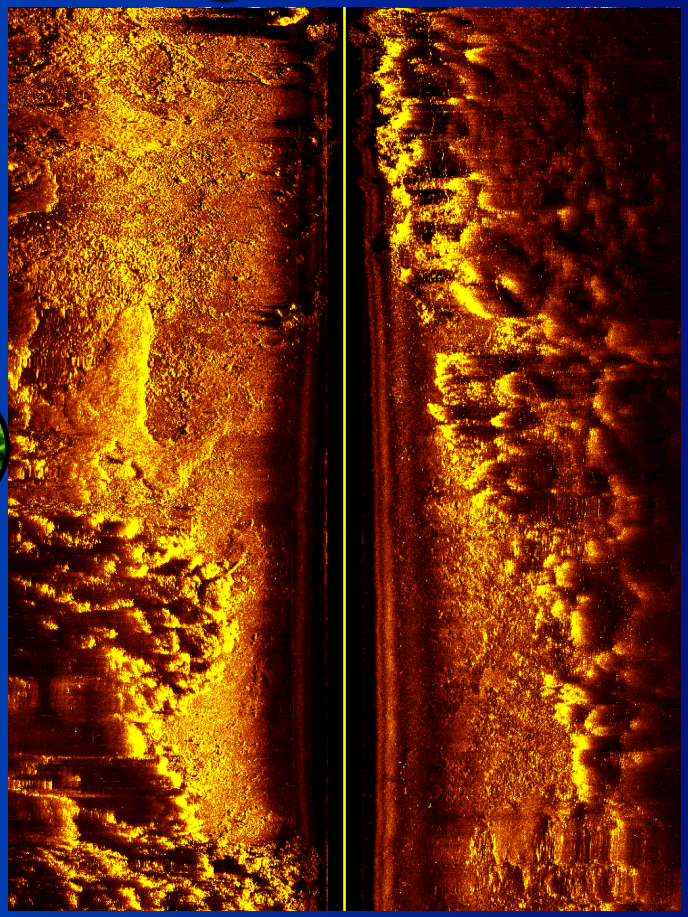
Manual interpretation of Sonar Images

Human interpretation based on

- features found in the image
- knowledge about the objects producing the features

-> requires expert knowledge

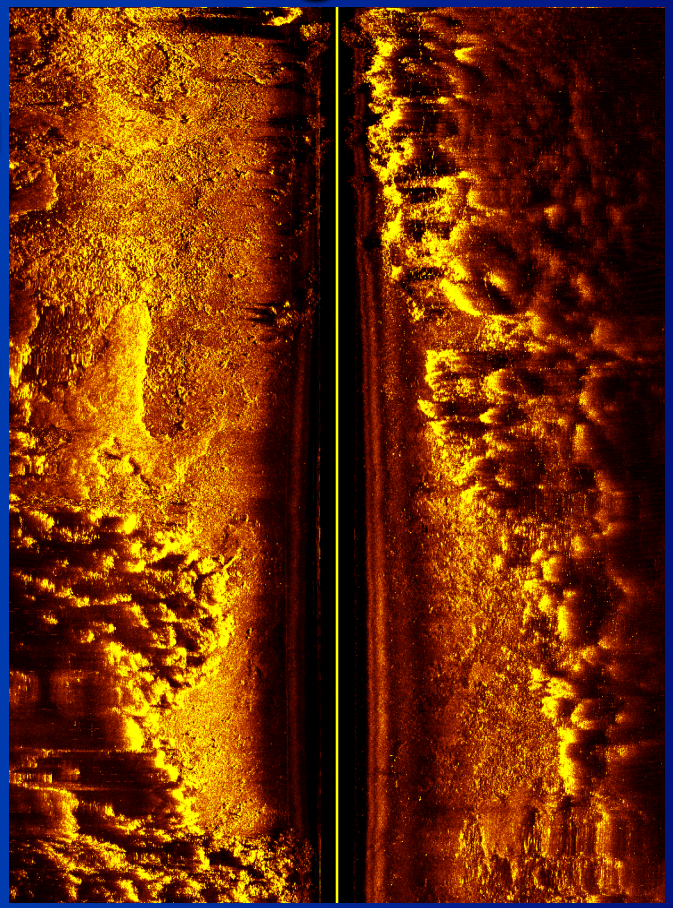




Automatic interpretation of Sonar Images

Use Artificial Neural Networks (ANN) for seabed recognition:

-> encapsulating expert knowledge in a pattern recognition model



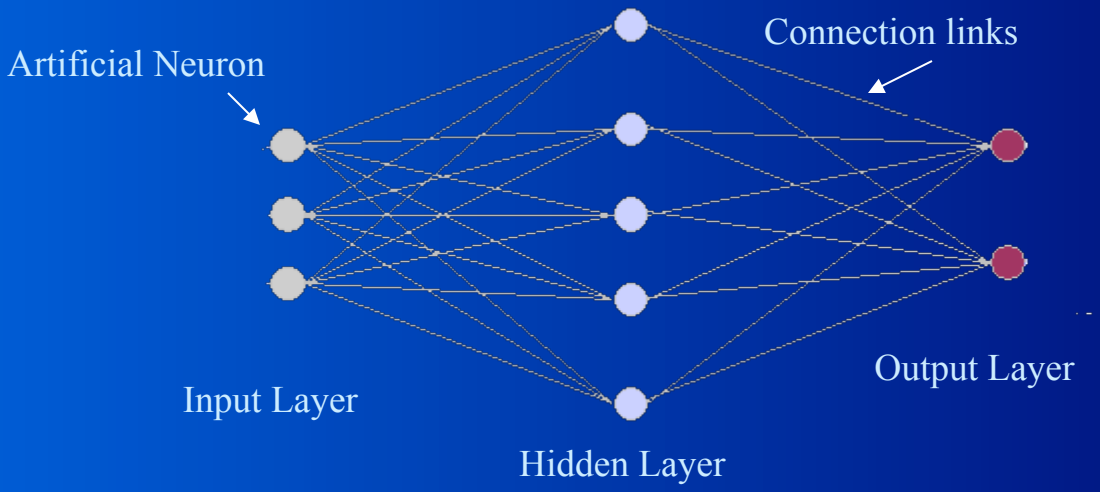
Properties of ANN

ANN's crudely mimic the human brain in two ways;

- Knowledge is acquired through a learning process.
- Interconnection strengths (weights) store the knowledge.

Learning in ANN

- Supervised
- Unsupervised



Three layer feed forward MLP network

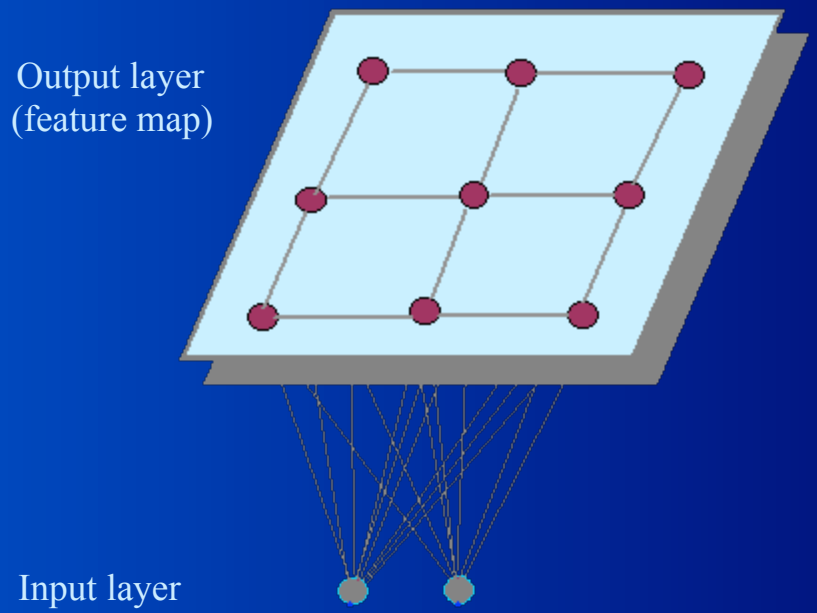
Learning in ANN

- Supervised learning
  - Learning from a set of examples (training set).
  - Training data is in Input- Desired output form.
  - The difference between desired output and actual output is minimized by modifying connection strength of neurons.

- Unsupervised learning
  - network learning is totally data driven
  - no desired output

Unsupervised Neural Networks

- Self Organizing Maps (SOM)
  - Two layers; Input layer and Output layer (feature map).
  - All inputs are connected to all the output neurons.
  - Each neuron in output layer has a weight vector of the same dimension as the input data vector.
  - No desired output to learn, so training is competitive based on similarity measurements



Two-dimensional Self Organizing Map

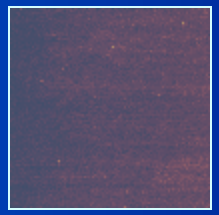
SOM Output

- Similar inputs are mapped to close neighborhoods in feature map.
- For every input, we get two information from the SOM ; the position of neuron fired and the feature vector associated with this neuron.
- Clustering in SOM is visualized by plotting the winner frequencies of each neuron for the data set.
- Trained SOM can be calibrated with known samples to use as a classifier.

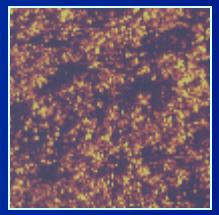
Texture features

One of the important characteristic that aid image interpretation is the texture of different regions.

- Texture - A complicated pictorial pattern produced by the spatial distribution of grey level variations.



Fine, uniform

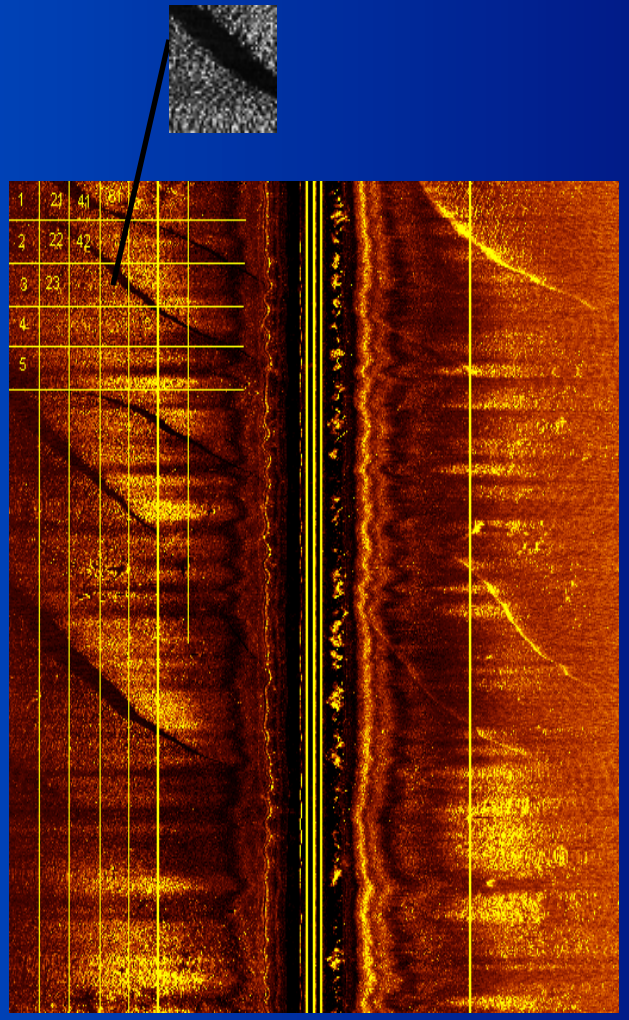


Coarse

- Two dimensions of texture:
  Tone - describe the primitives out of which texture is composed.
  Texture - describe spatial dependencies between primitives

Feature Extraction

- Sonar image converted to number of user defined pixel size bitmaps for SOM clustering.
- Purpose: Extracted features can be used for clustering and classification.



Sonar image from sandy seabed

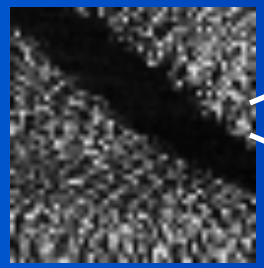
Feature Extraction

Cooccurrence Matrix (Texture features)

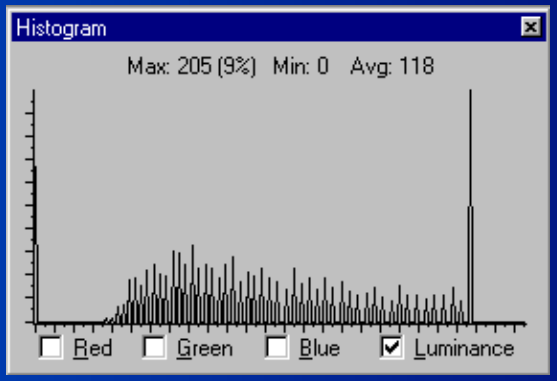
-energy

-entropy

-momentum



0	0	1	1
0	0	1	1
0	2	2	2
2	2	3	3



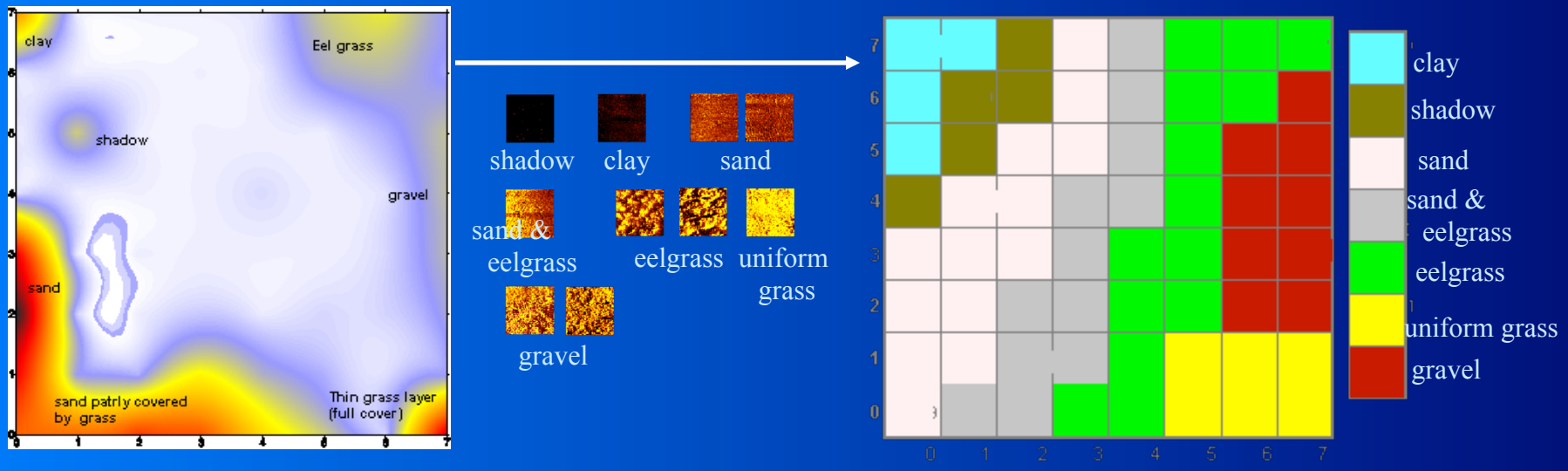
Gray level histogram (Tone features)

-median

-3rd quartile

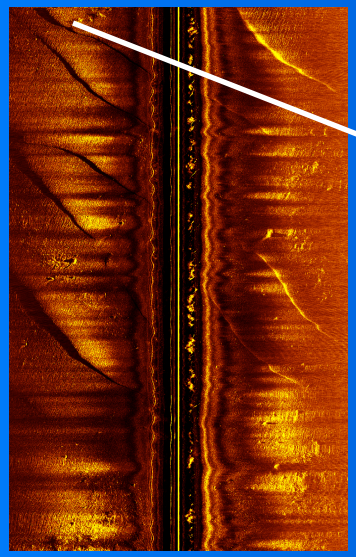
Calibration of trained SOM

- Seven clusters are located from the plot of winner counts.
- A small subset of known input data has been used to identify the clusters in SOM.

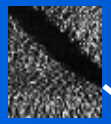


Seabed Recognition - system overview

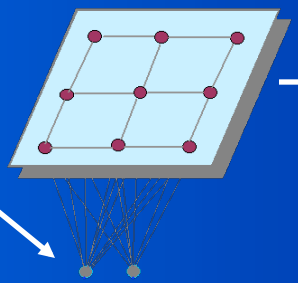
Sonar Image



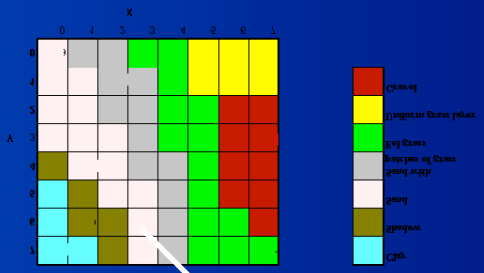
Feature Extraction



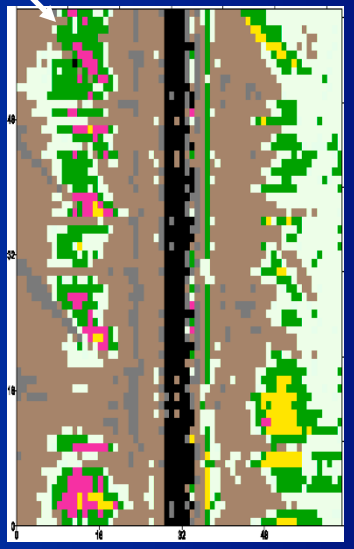
ANN



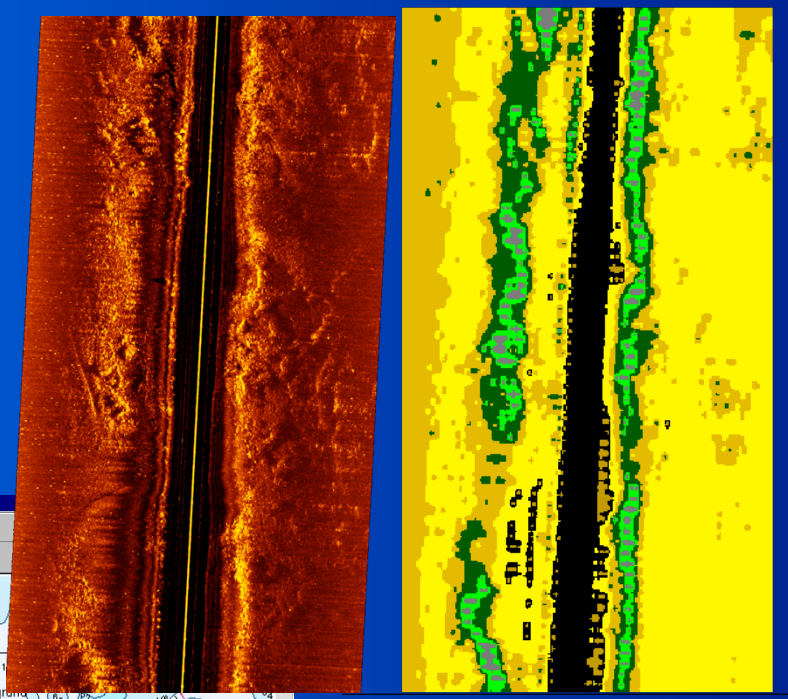
Classifier

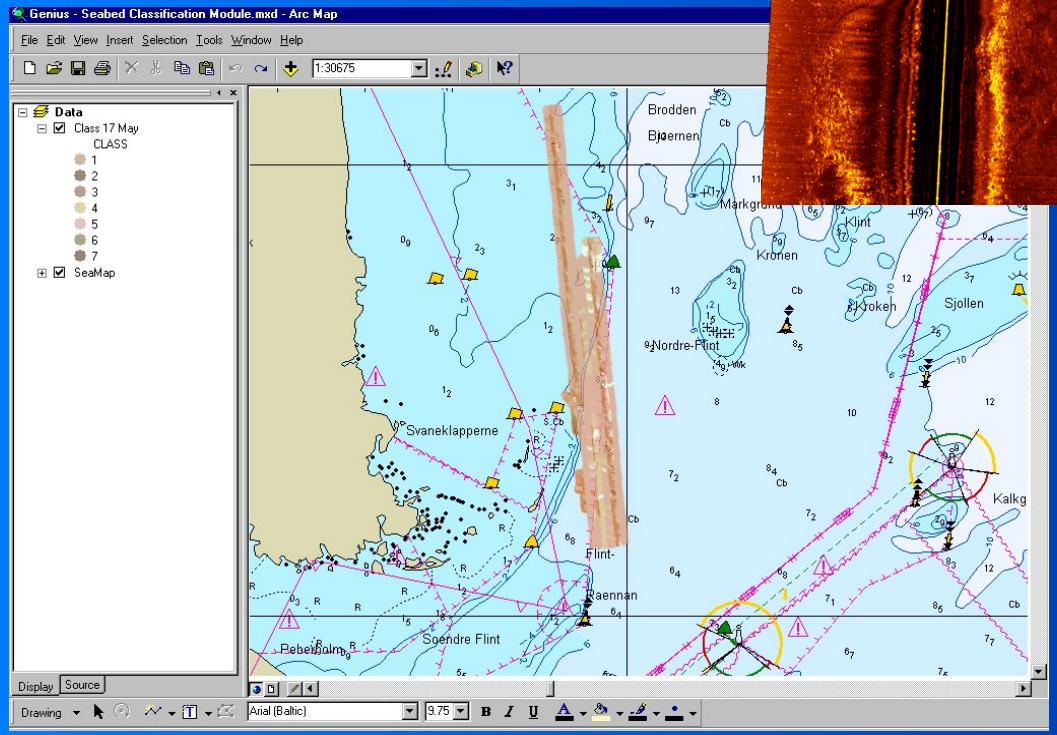


Visualization



Classification





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- Clay
- Shadow
- Sand
- Sand with patches of grass
- Eelgrass
- Uniform grass layer
- Gravel
- No Data

Summary and Conclusions

- Unsupervised neural network has been used for data exploration and feature selection for sonar image classification.
- Unsupervised network proved to be a useful tool for data exploration.
- Texture features are used in combination with feature of the grey level histogram of image segments.
- Features selected from SOM training for classification are median and 3rd quartile of grey level histogram and texture features energy, entropy and momentum.

Thank You