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Title:	Recent Work and Results on Sparrow Project
Author(s):	Neal R. Harvey
Intended for:	Sending to project sponsor, to update on progress and plans

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Form 836 (7/06)

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Title: Recent Work and Results on Sparrow Project

Author: Neal R. Harvey, ISR-2

Abstract:

This briefing describes recent work undertaken on the Sparrow Project and results of this work. It describes experiments comparing the use of Genie with 2 classes with 3 classes for the problem of ship delineation. It also describes some preliminary work in the area of the optimization of segmentation techniques.

Recent Work and Results on Sparrow Project

Neal R. Harvey
LANL
December 2010

Using Genie to Separate Vessels From Wake: 2-Class versus 3-Class

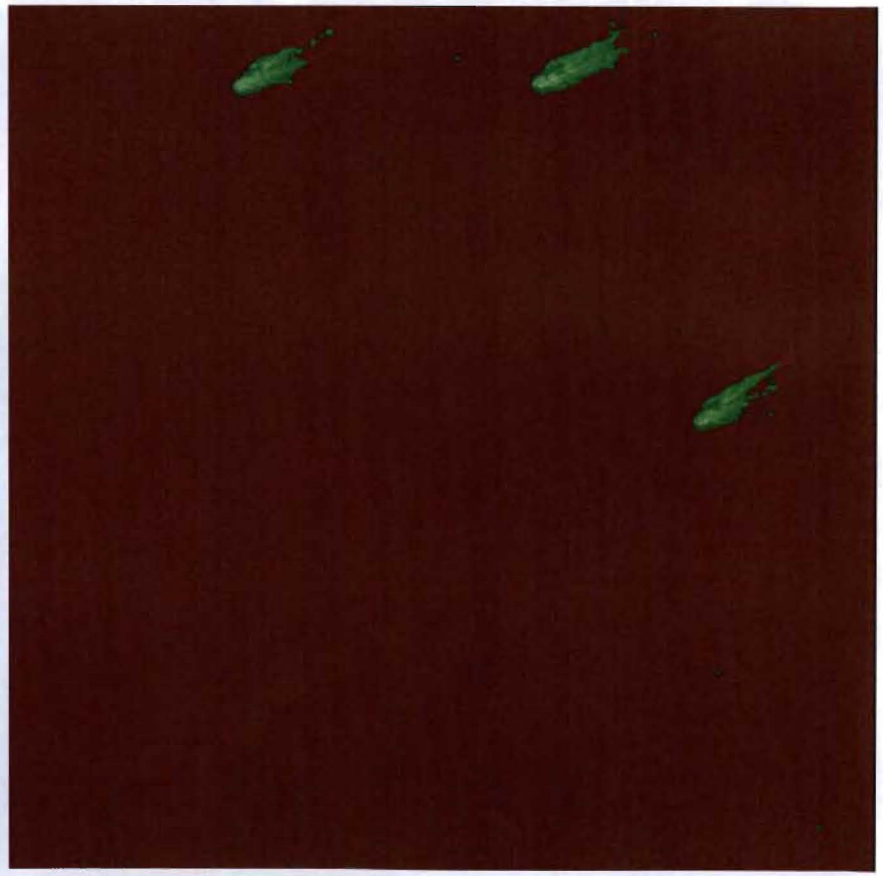
Early (limited) Experiments

- Increasing number of classes from 2 (ship vs background) to include a 3rd (wake) class
- Initial experimental results showed some promise for this approach
  - Ship segmentation – closer to size and shape of actual ship when including wake class

Ship detection: 3-class vs 2-class with Genie

Multi-class (including wake class)

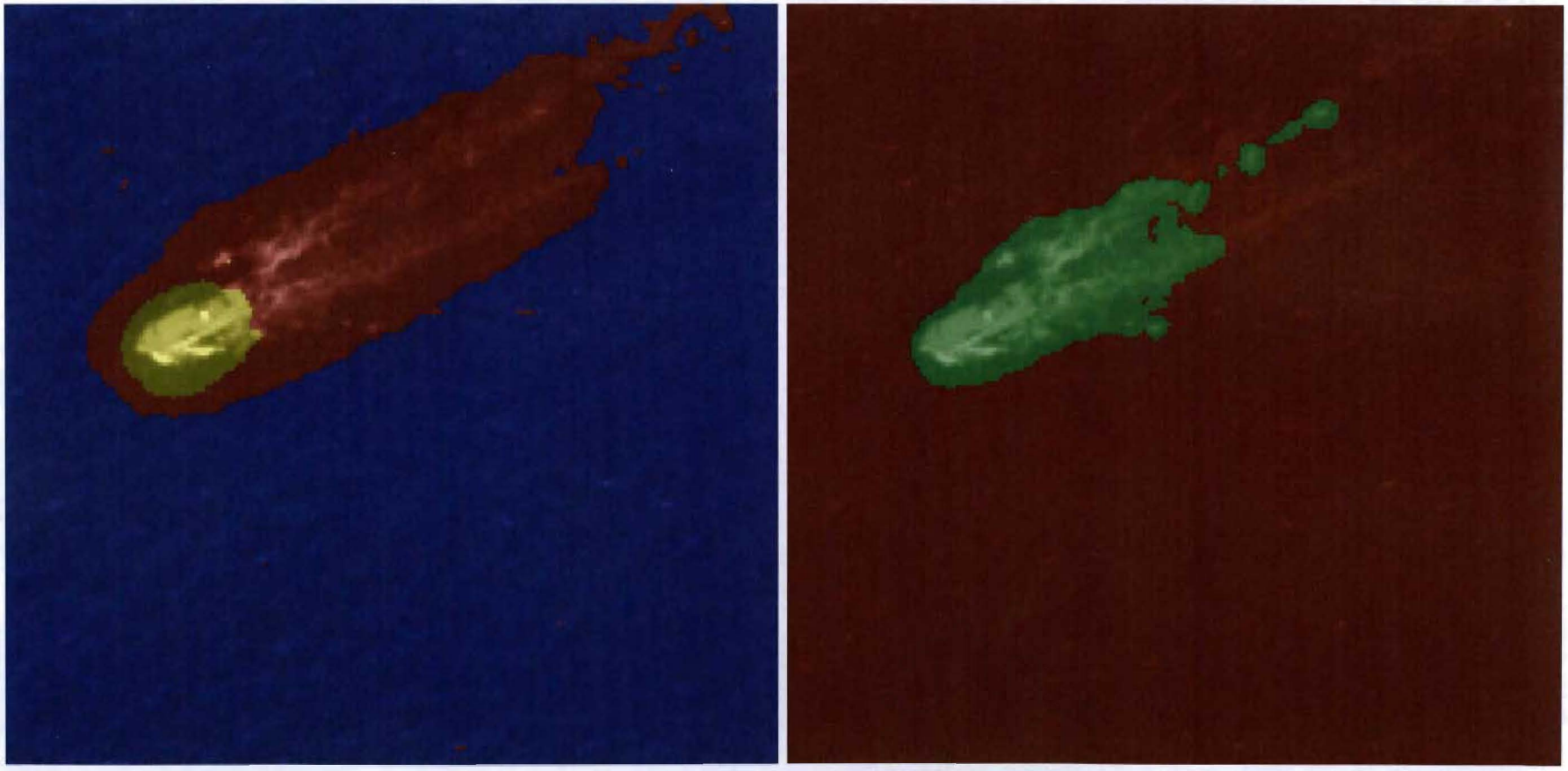
2-class



Ship detection: 3-class vs 2-class with Genie

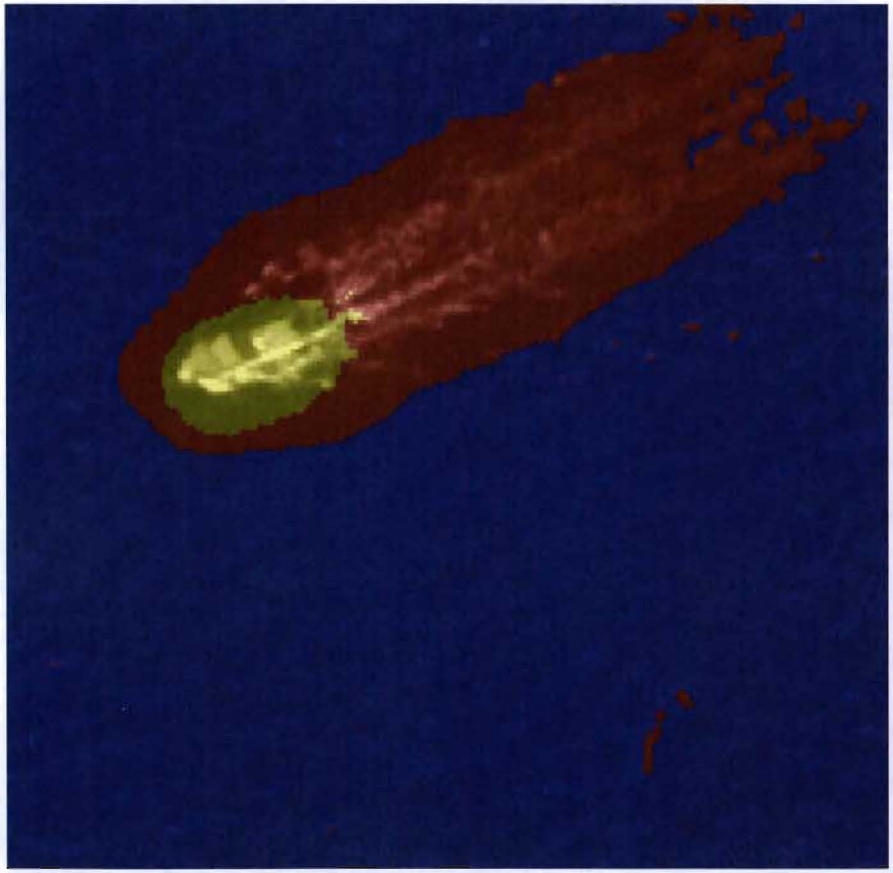
Multi-class (including wake class)

2-class

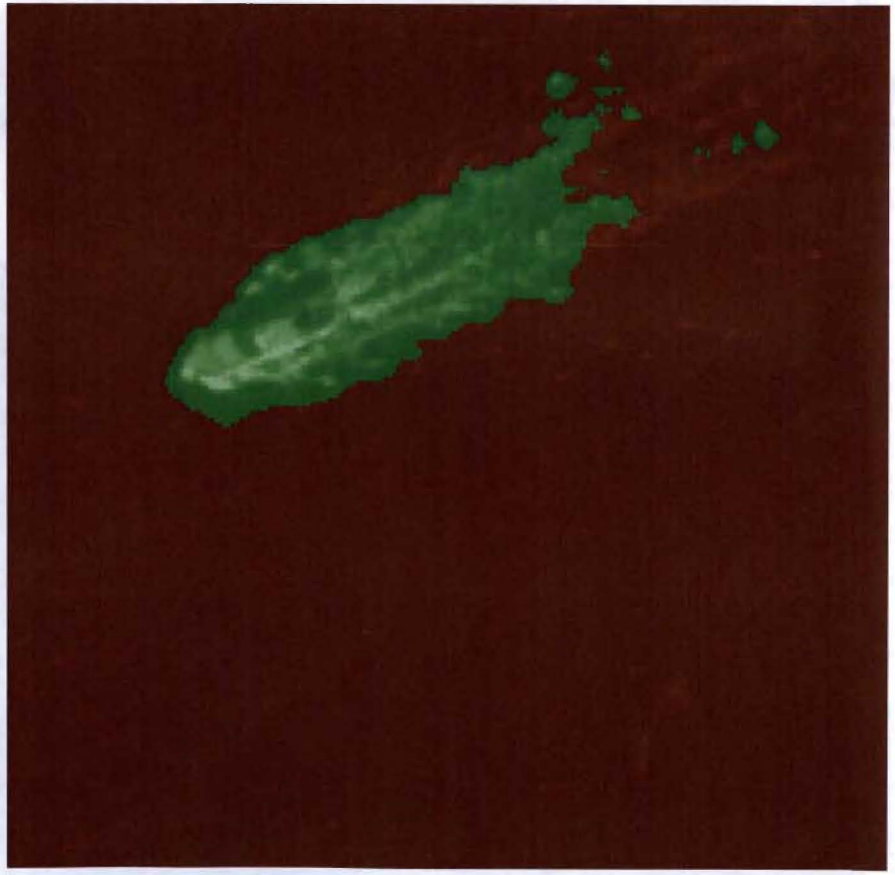


Ship detection: 3-class vs 2-class with Genie

Multi-class (including wake class)

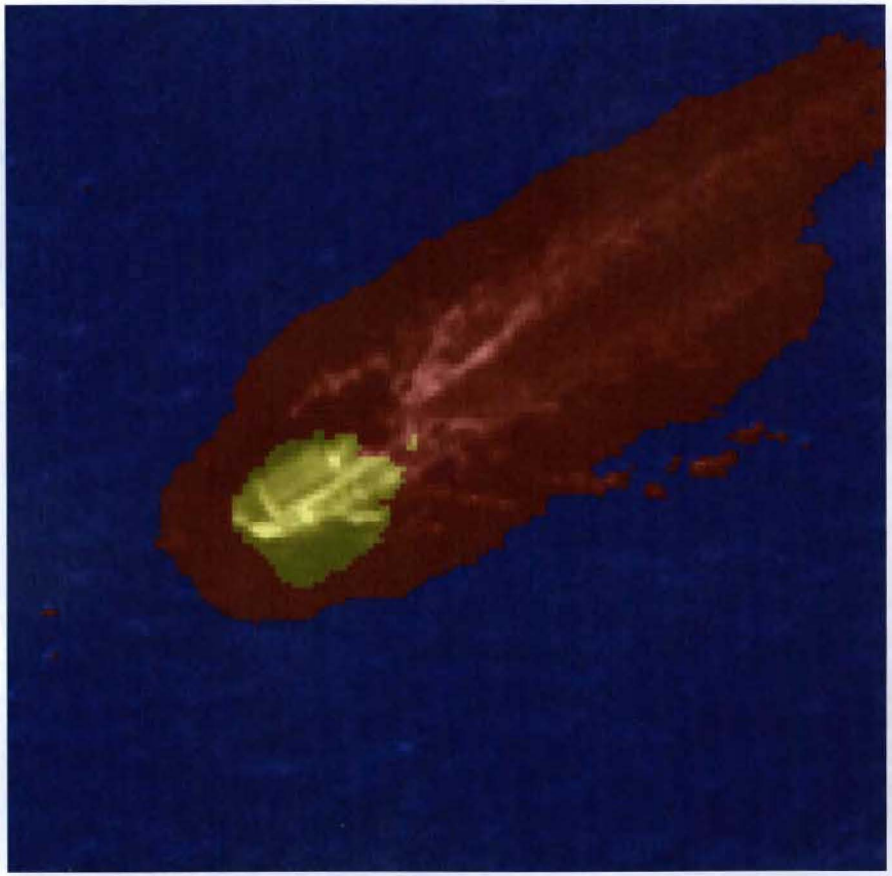


2-class

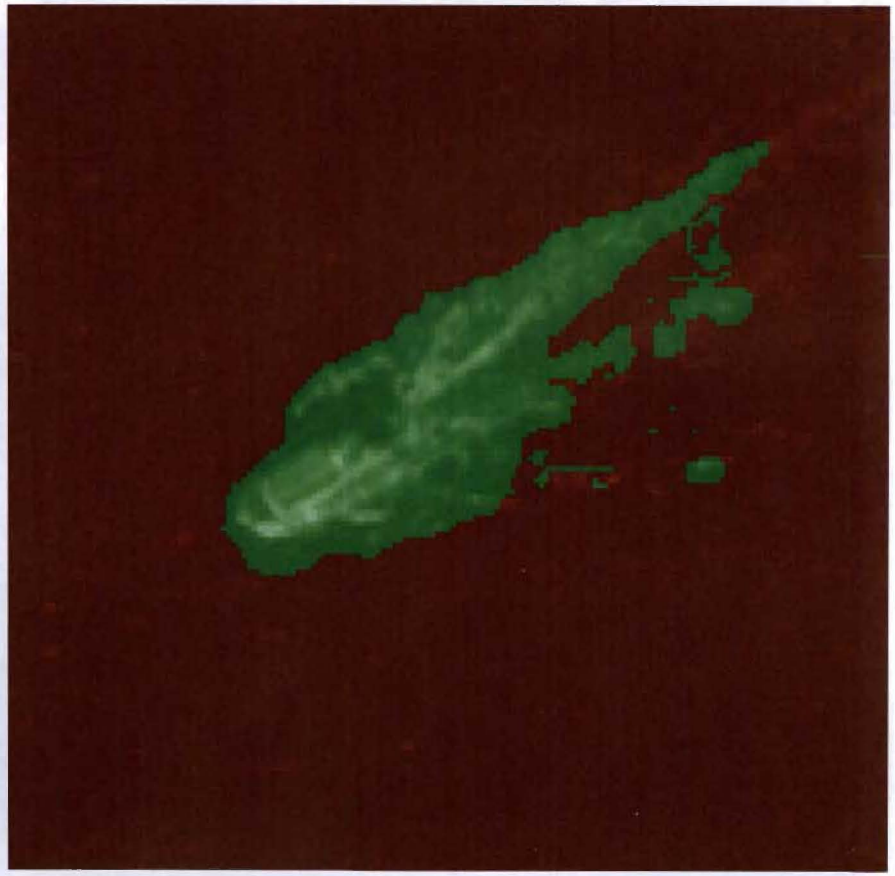


Ship detection: 3-class vs 2-class with Genie

Multi-class (including wake class)



2-class



Initial Experiments

- Used very limited data for training and testing
- No objective measures for comparisons

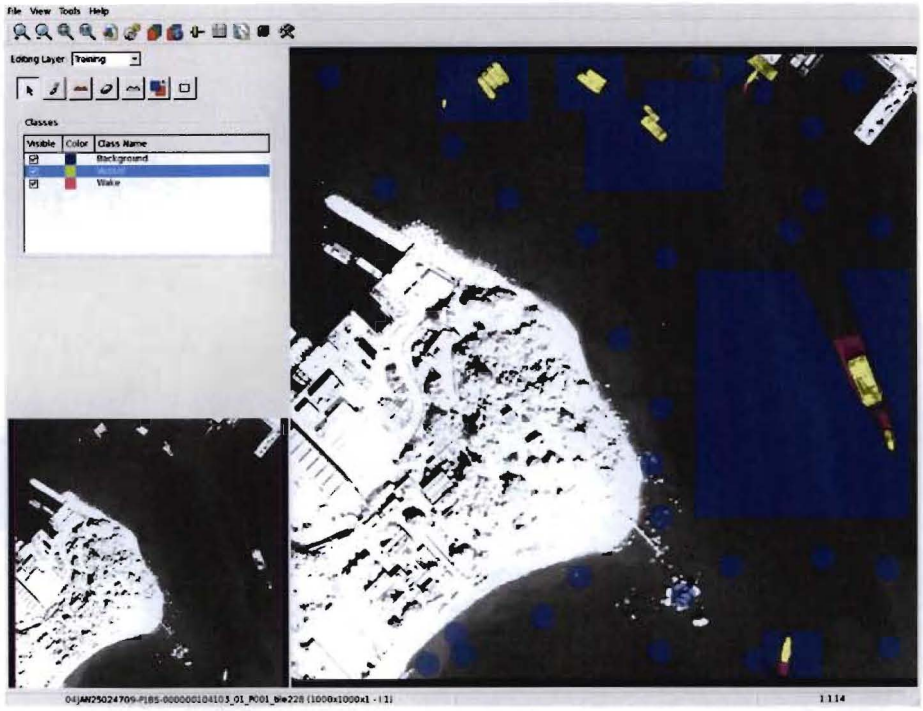
- Need for more through investigation
  - using more data
    - and
  - objective measure for comparisons

More Thorough Investigation: Training Data

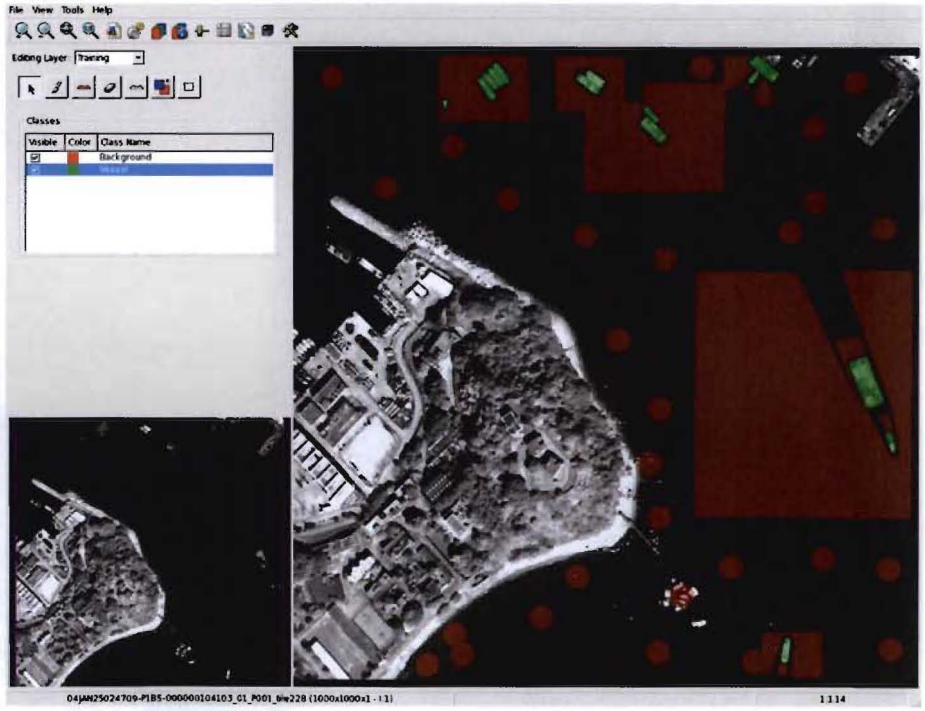
- Marked-up 168 1000x1000 tiles
  - 3 classes:
    - Ship
    - Wake
    - Background
  - 2 classes:
    - Ship
    - Background
      - (formed from merging Wake and Background classes from 3-class examples)

Example Mark-up

3-class Mark-up



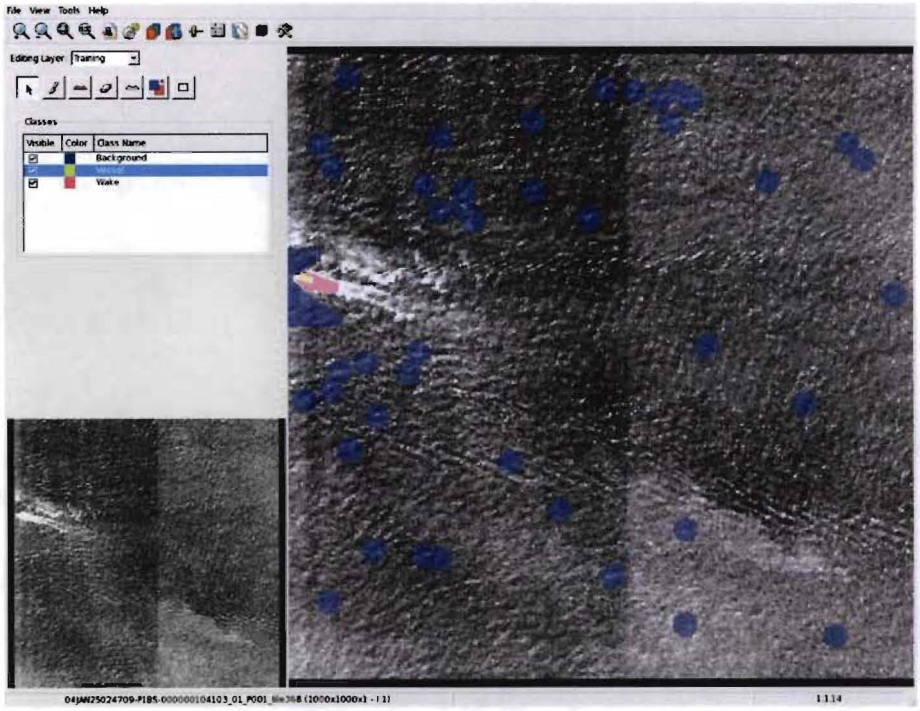
2-class Mark-up



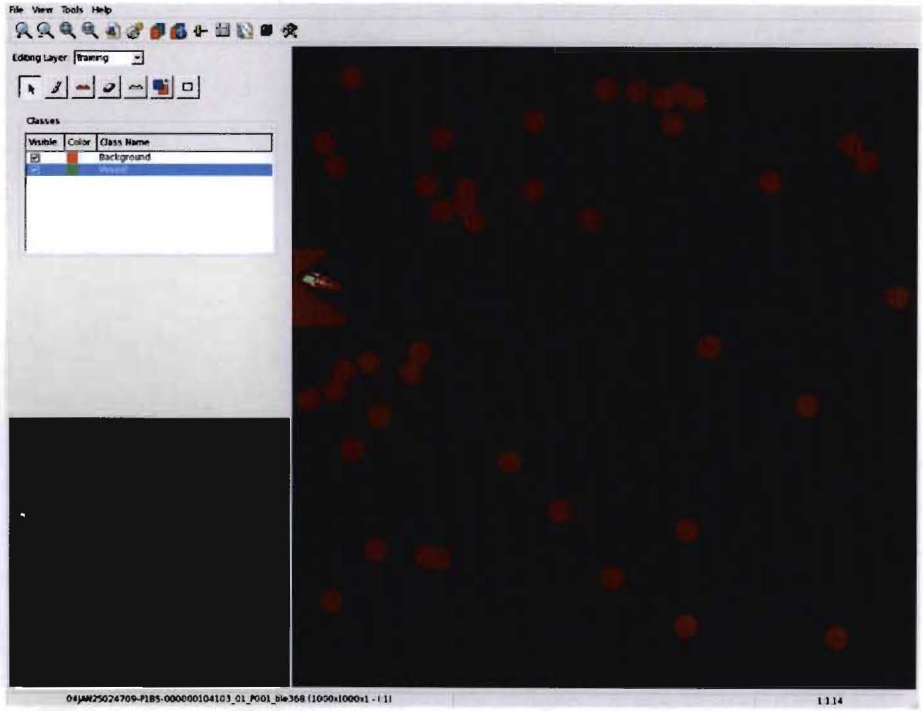
Note: Image on left has different contrast stretch – to show how details of sea state and ship can be more or less visible, depending on how one adjusts the contrast

Example Mark-up

3-class Mark-up



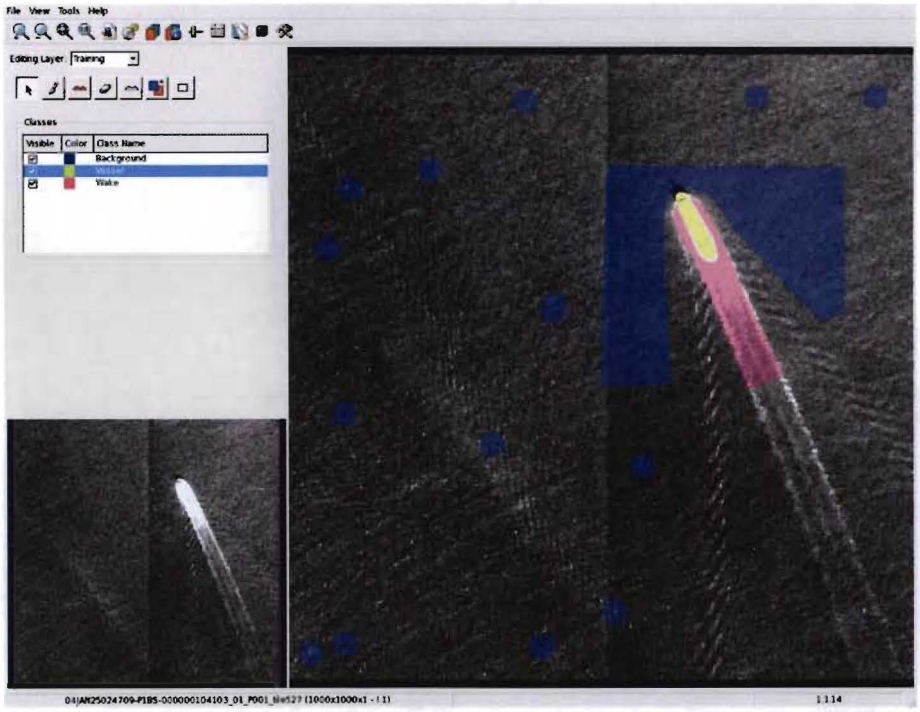
2-class Mark-up



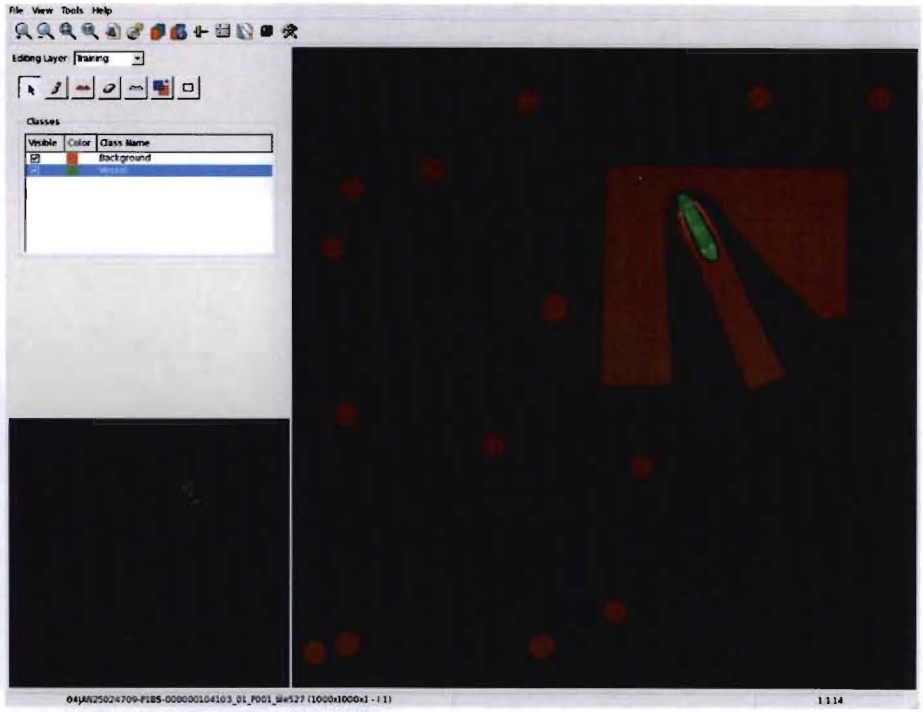
Note: Image on left has different contrast stretch – to show how details of sea state and ship can be more or less visible, depending on how one adjusts the contrast

Example Mark-up

3-class Mark-up



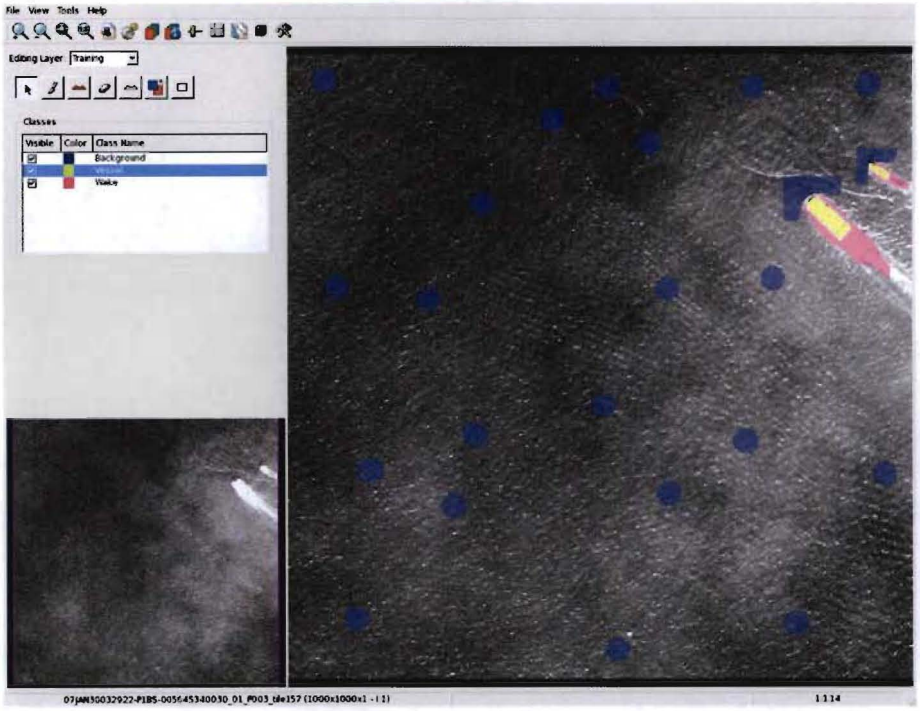
2-class Mark-up



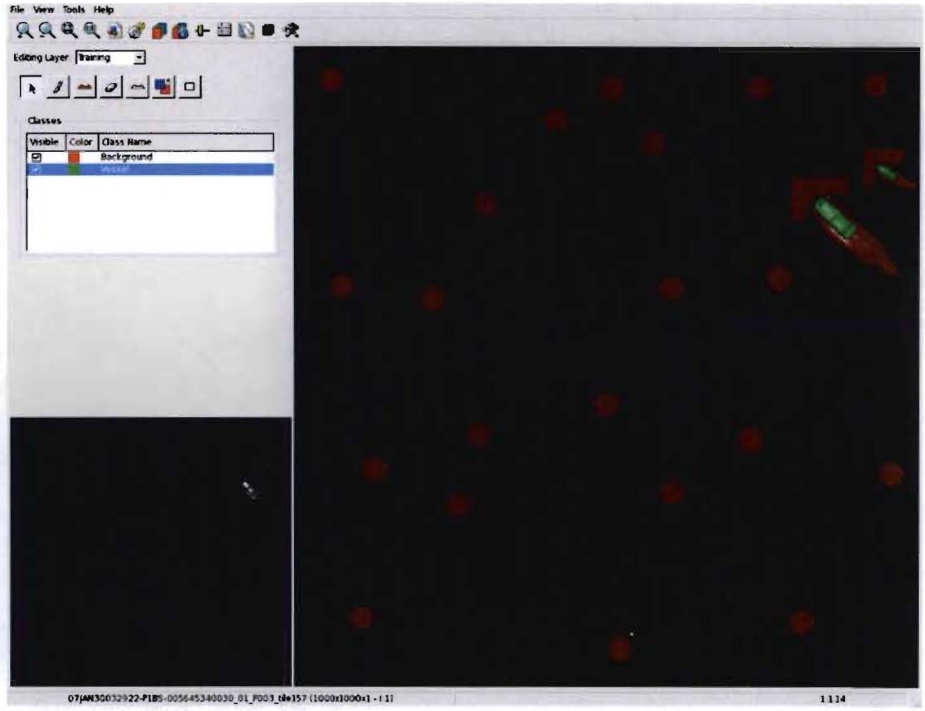
Note: Image on left has different contrast stretch – to show how details of sea state and ship can be more or less visible, depending on how one adjusts the contrast

Example Mark-up

3-class Mark-up



2-class Mark-up



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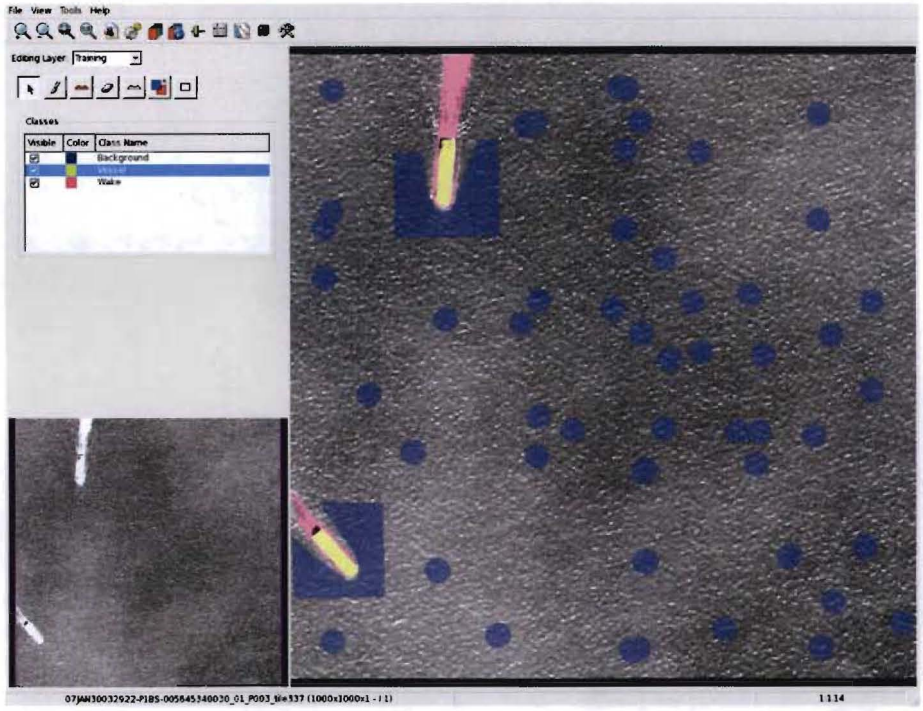
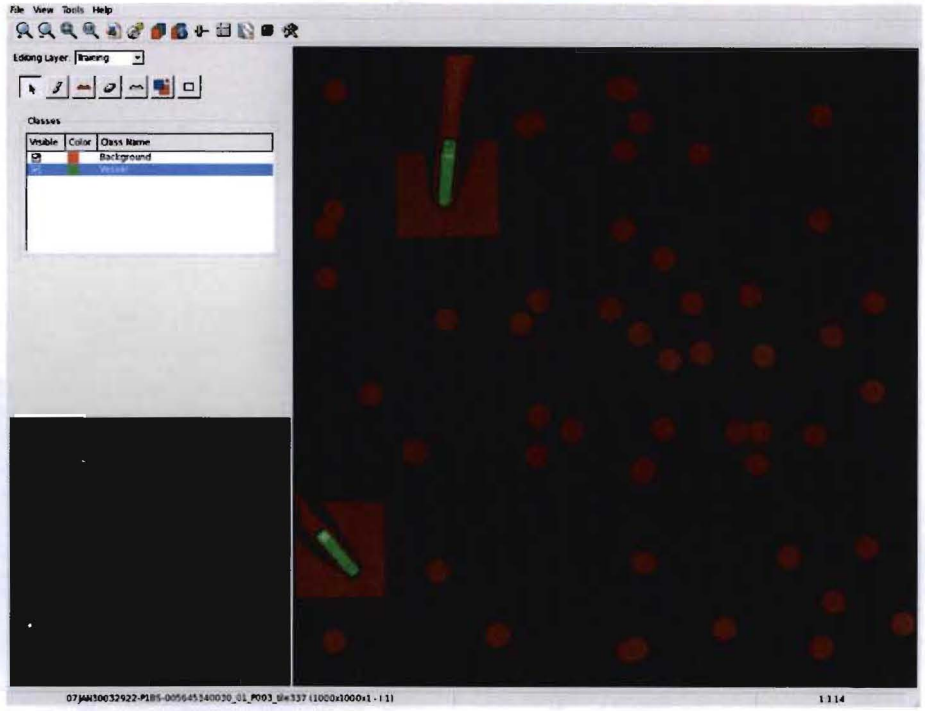
Example Mark-up

3-class Mark-up



2-class Mark-up

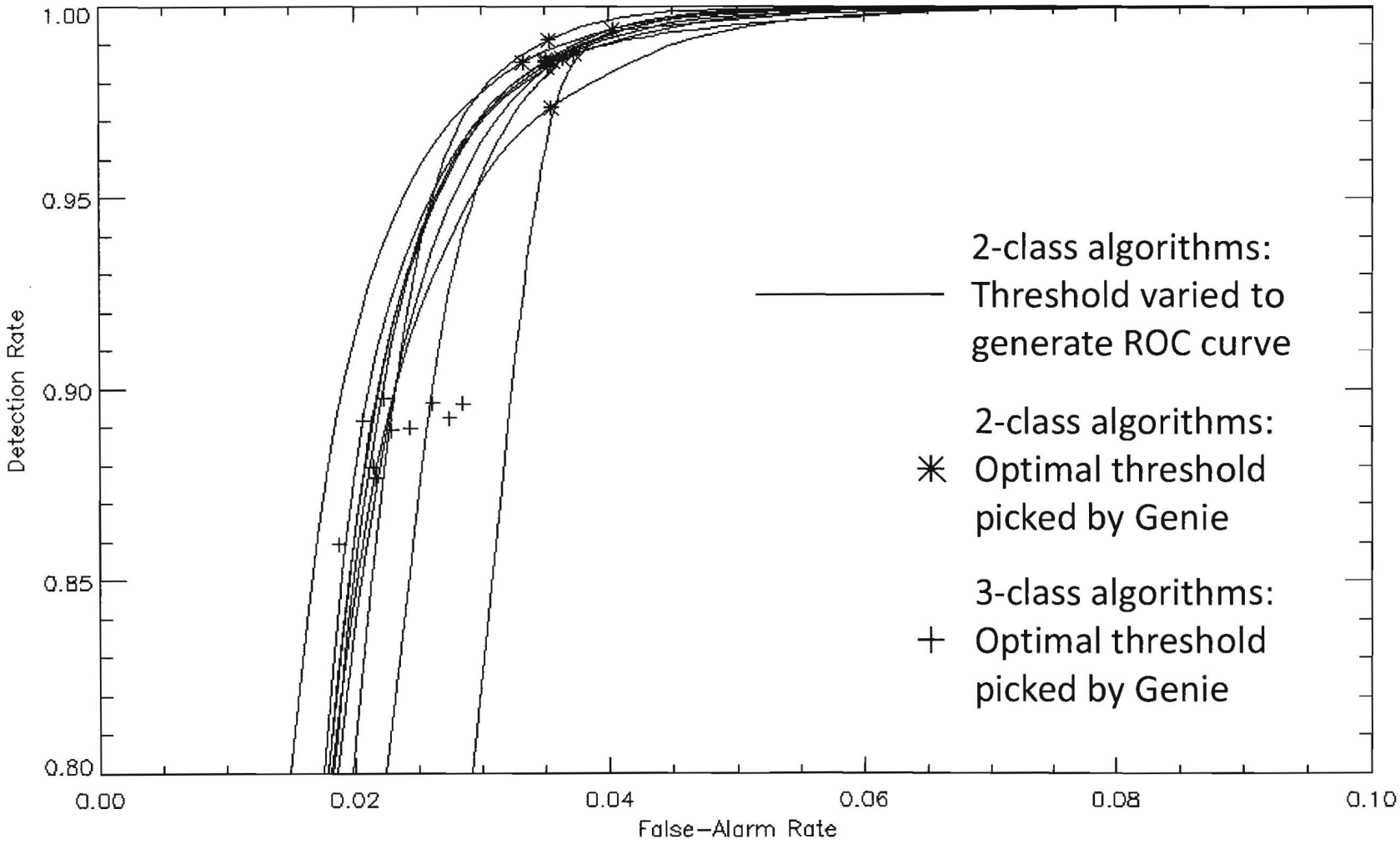


Note: Image on left has different contrast stretch – to show how details of sea state and ship can be more or less visible, depending on how one adjusts the contrast

More thorough investigation: training and performance measures

- Trained Genie classifiers (AFE mode)
  - 10 classifiers for 3-class
  - 10 classifiers for 2-class
- Applied the resulting Genie classifiers to all 168 images
- Calculated:
  - Detection Rate (DR)
  - False-Alarm Rate (FAR)
  - Score (500 * (DR + (1.0 – FAR)))

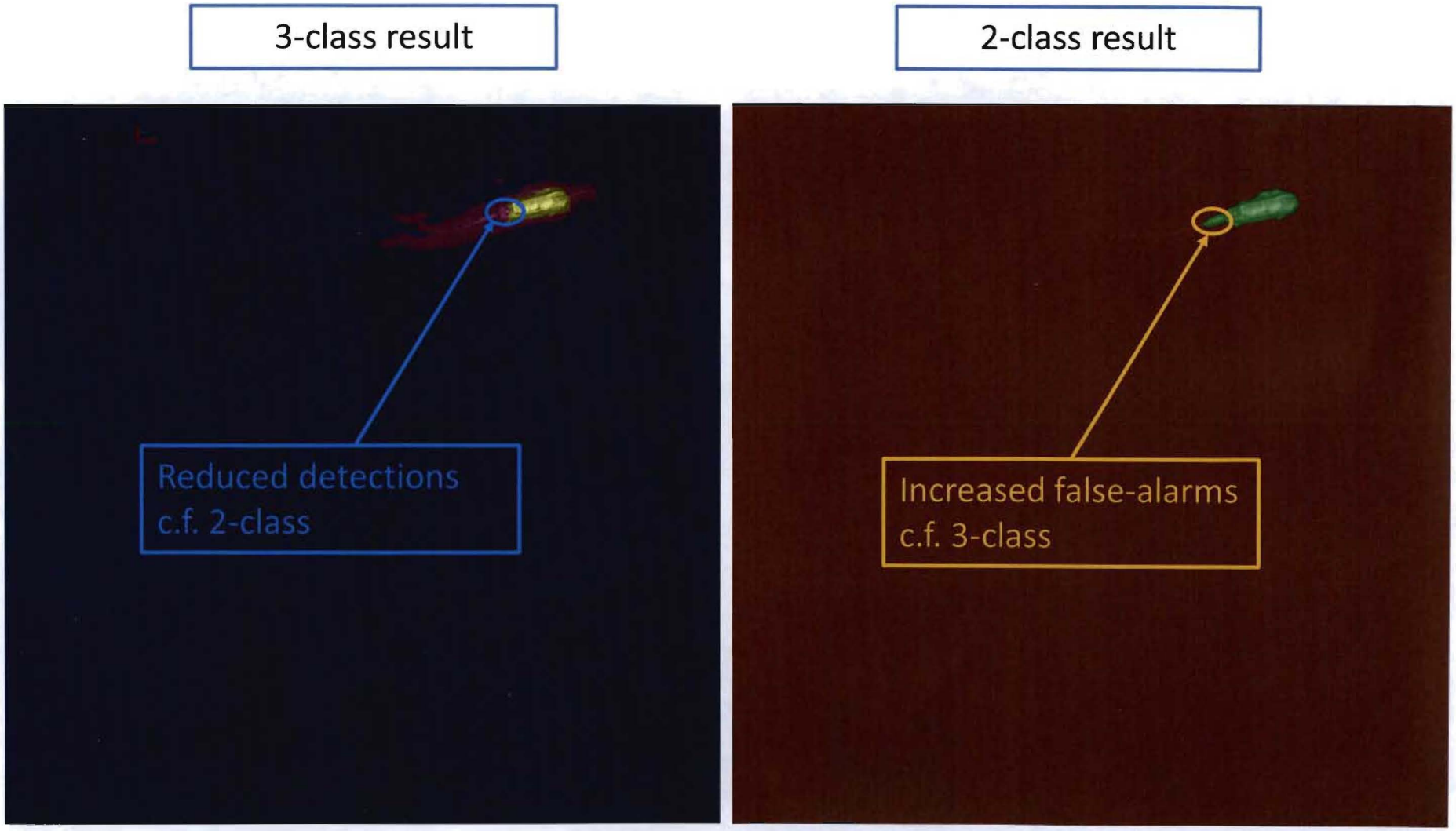
Results: Testing Data



Results: 3-class VS 2-class

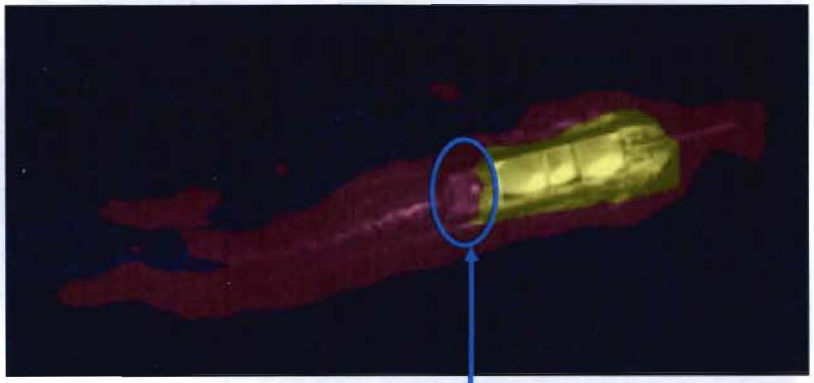
- Not clear that 3-class buys us anything in performance compared to the 2-class
- For the "optimal" thresholds determined by Genie:
  - 3-class has significantly lower false-alarm rates compared to 2-class.
  - However, 3-class also has significantly lower detection rates compared to 2-class

Example Result Comparisons



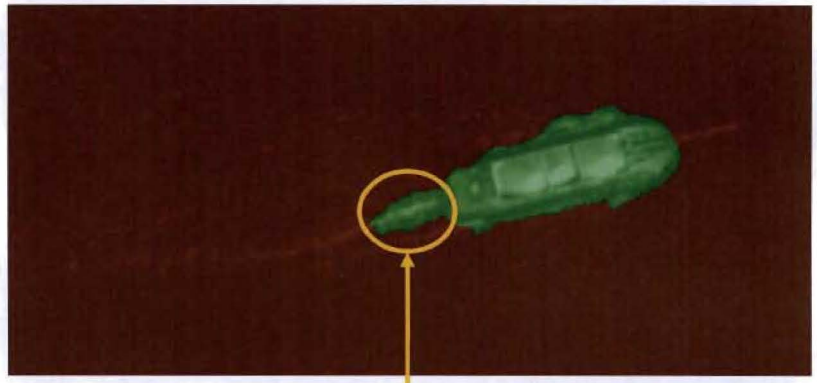
Example Result Comparisons

3-class result



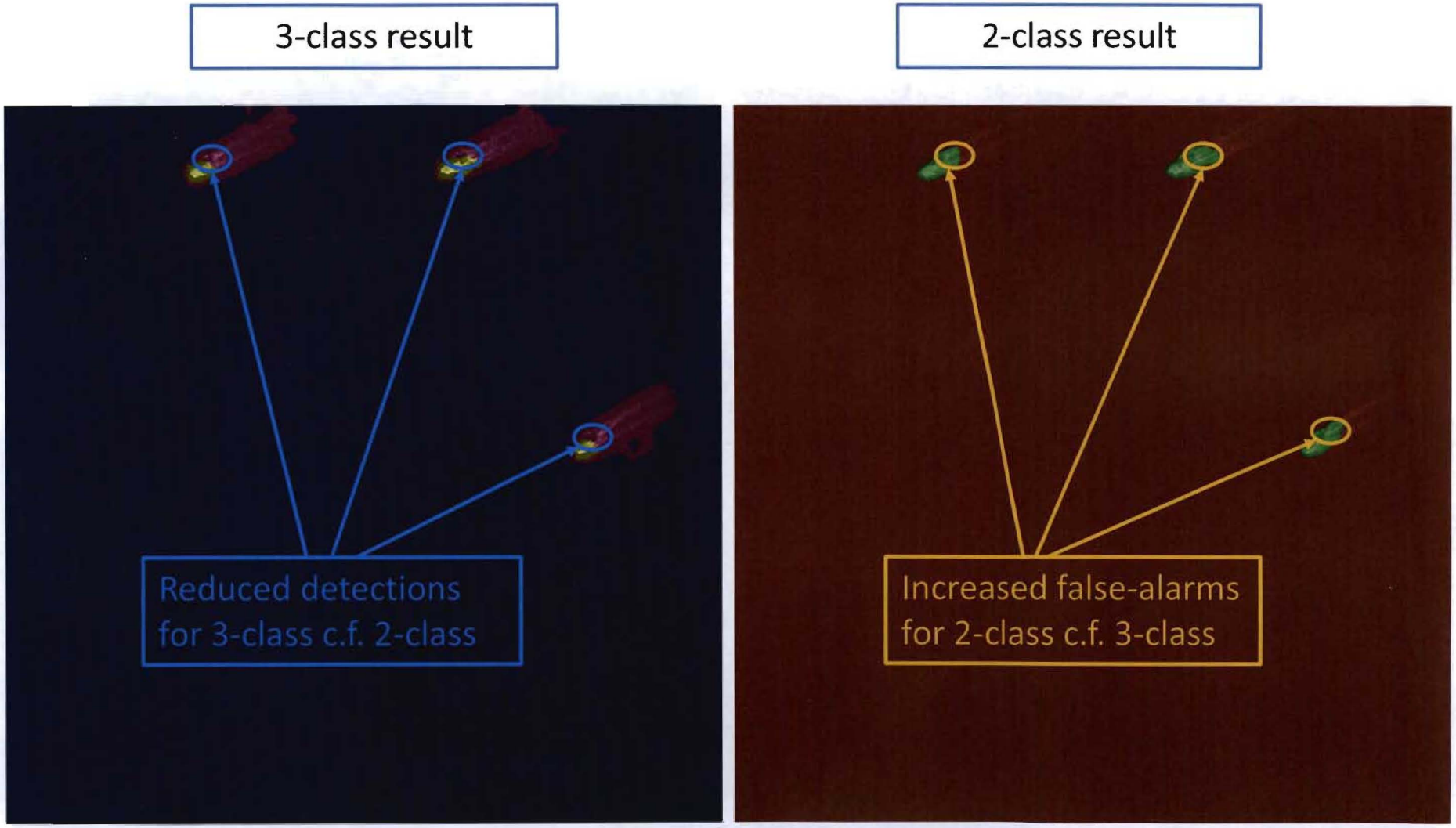
Reduced detections
for 3-class c.f. 2-class

2-class result

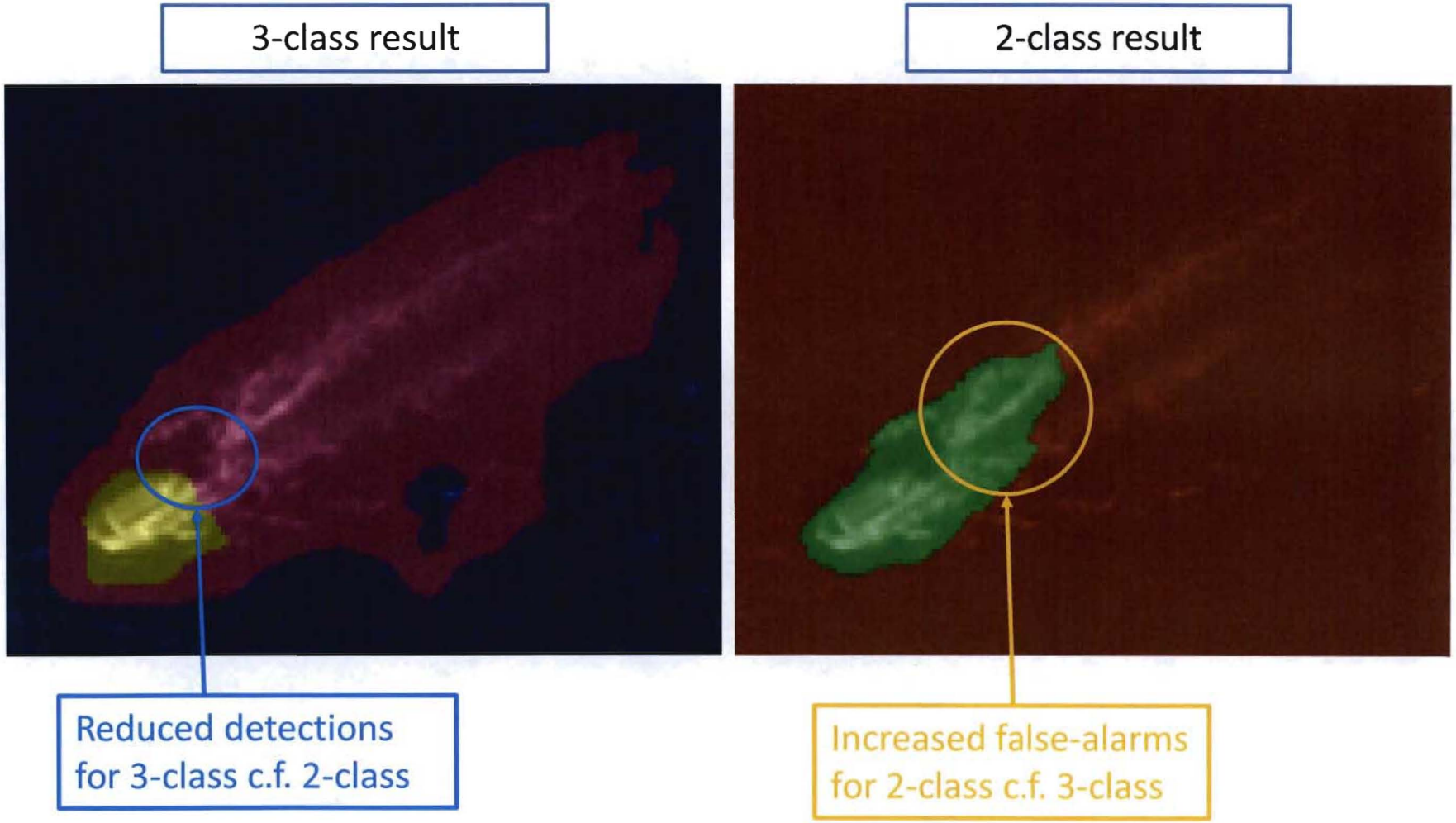


Increased false-alarms
for 2-class c.f. 3-class

Example Result Comparisons



Example Result Comparisons



Further possible work in this area (Genie for segmenting ships)

- Modify Genie to have a weighting for each class.
  - Obviously, we are ultimately interested in having accurate ship segmentation
  - Not so bothered if the wake class and background class get incorrect labels
    - So long as the ship class gets the correct labels
  - Could include a greater weighting for the ship class
- Could use Genie 2-class to separate "ship + wake" class from background
  - Then use Genie 2-class to separate "ship + wake" into "ship" and "wake"

Segmentation
i.e. delineating ships

Segmentation

- Looking at optimizing segmentation algorithms
- Performance of a segmentation algorithm is affected a great deal by the type of processing that has preceded the actual segmentation step
- Usually – don't segment the original image
  - Leads to over-segmentation
- Some kind of pre-processing prior to segmentation step
- Type of pre-processing most useful will depend on the characteristics of the data and the objects of interest in the image

Segmentation Optimization

- Given some ground truth (training data marked up by a human expert)
  - Can we learn an "optimal" pre-processing pipeline?

Initial work

- If we want to optimize
  - 1st thing we need to
    - some way of measuring what is optimal
    - i.e. "fitness"
- Found several papers detailing measures for evaluating segmentation
  - Implemented one:
    - 1995, Huang & Dom, "Quantitative Methods of Evaluating Image Segmentation"

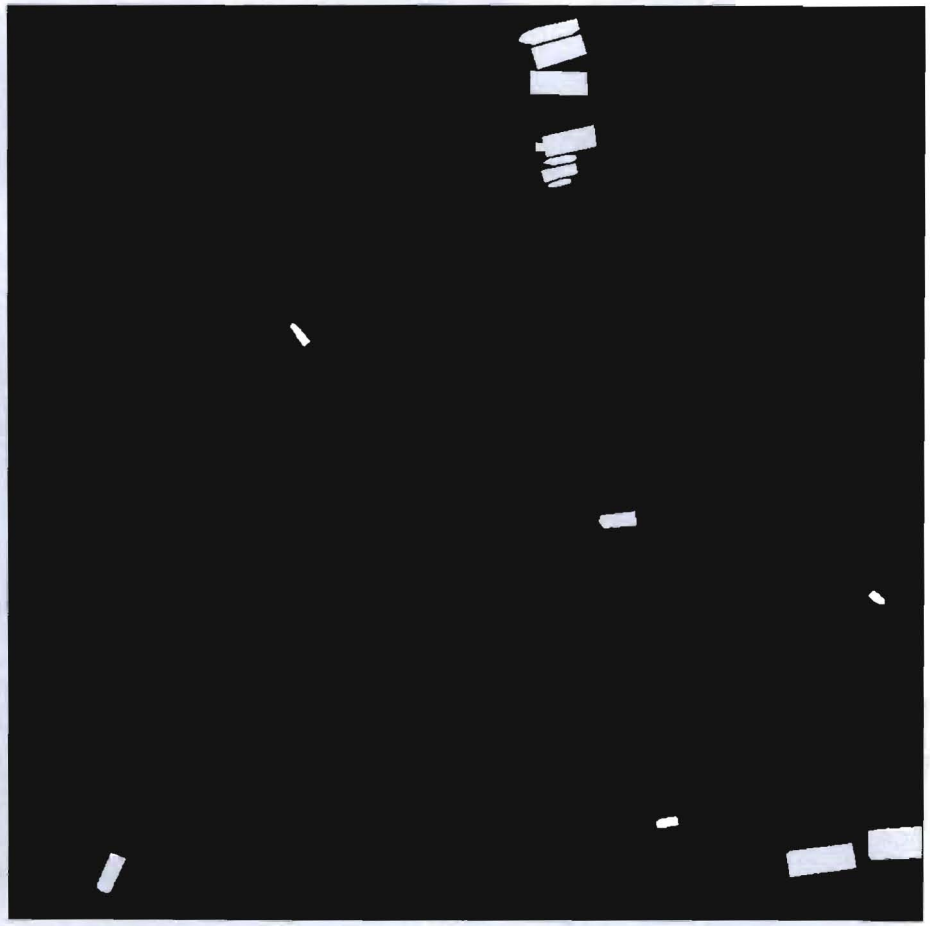
Preliminary Experiments

- Took example “test” image
- Marked up examples of objects of interest in the image
- Produced several “pre-processed” versions of the image
  - In this case, morphological smoothings of various radii
- Fed the morphological gradients of these smoothed versions to the watershed segmentation algorithm
- Calculated the fitness of each segmentation

Test Image

Original Image

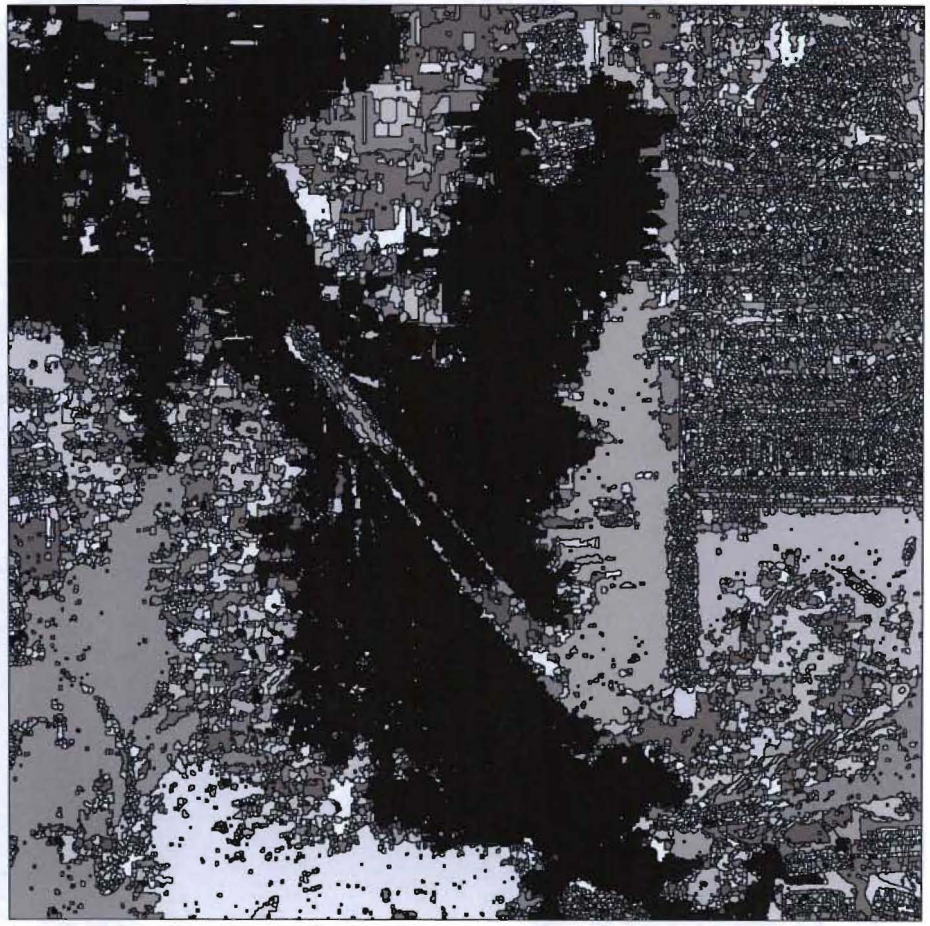
Ground Truth



Segmented Test Images

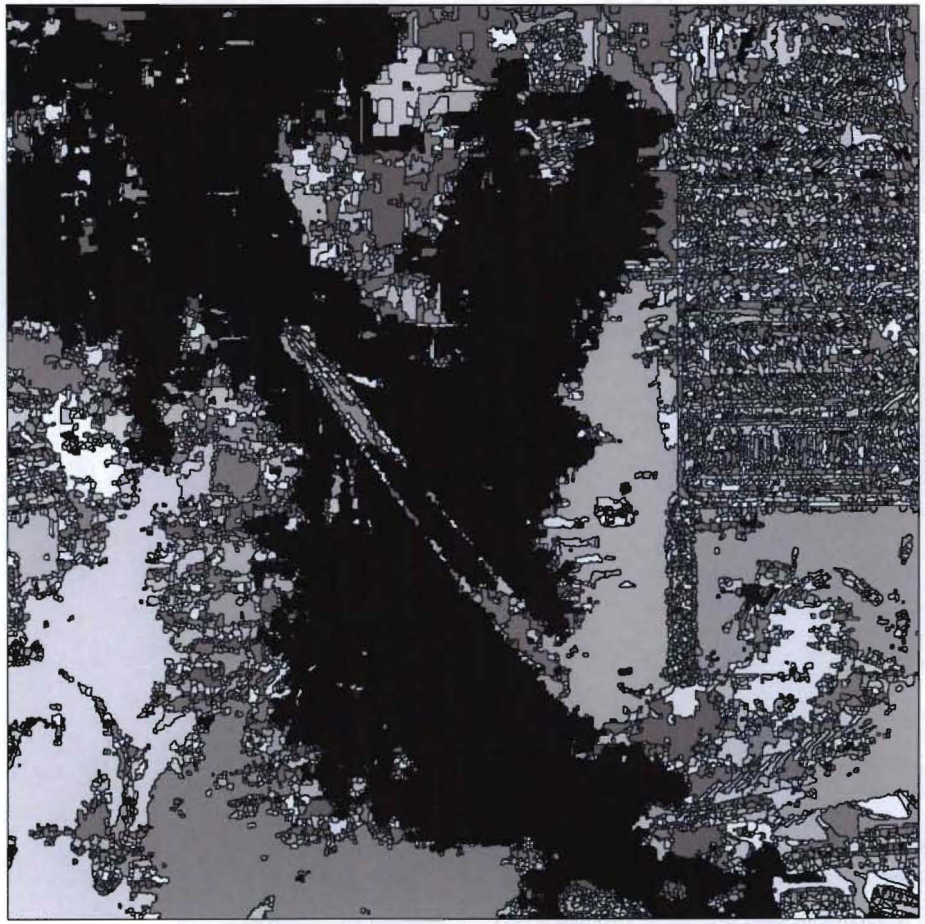
Segmented Unprocessed Image (radius = 0)

Segmented Smoothed Image (radius = 1)

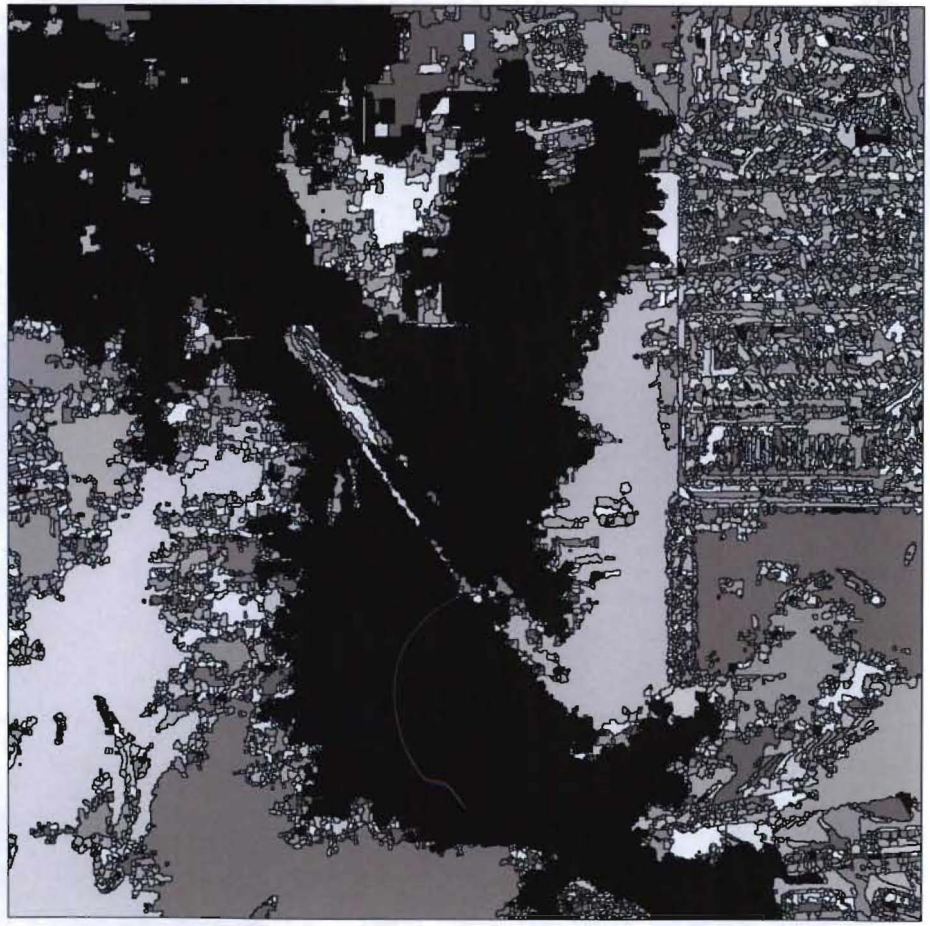


Segmented Test Images

Segmented Smoothed Image (radius = 2)

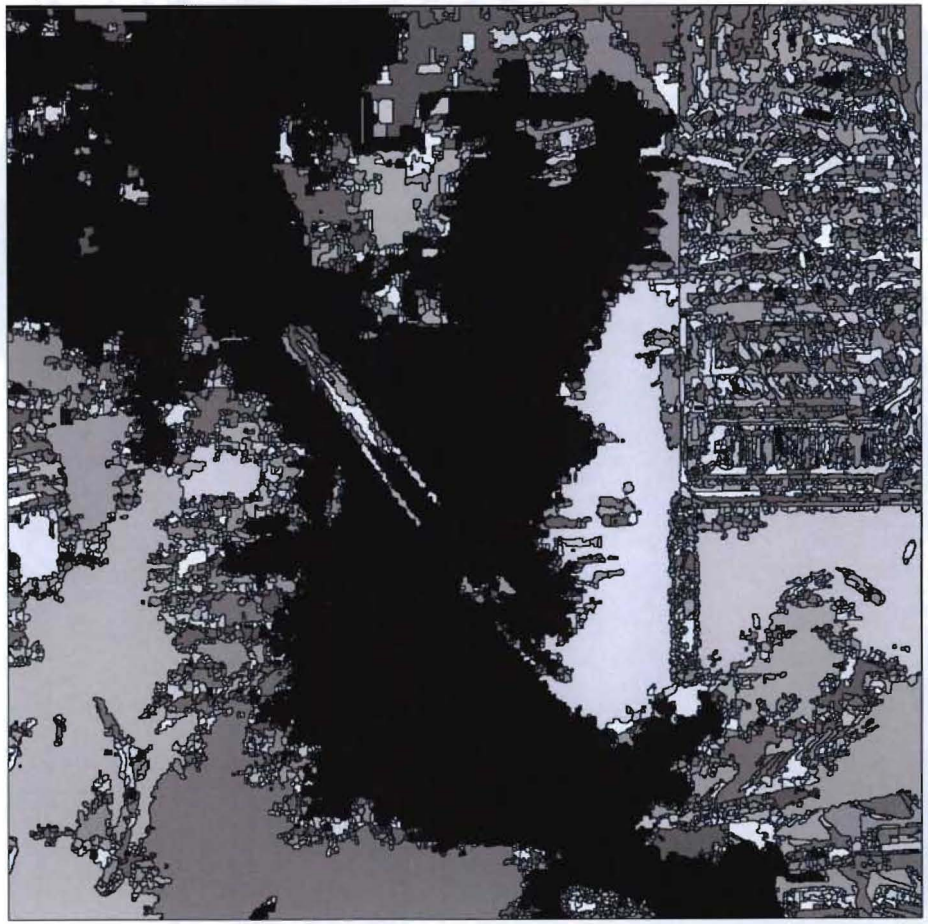


Segmented Smoothed Image (radius = 3)

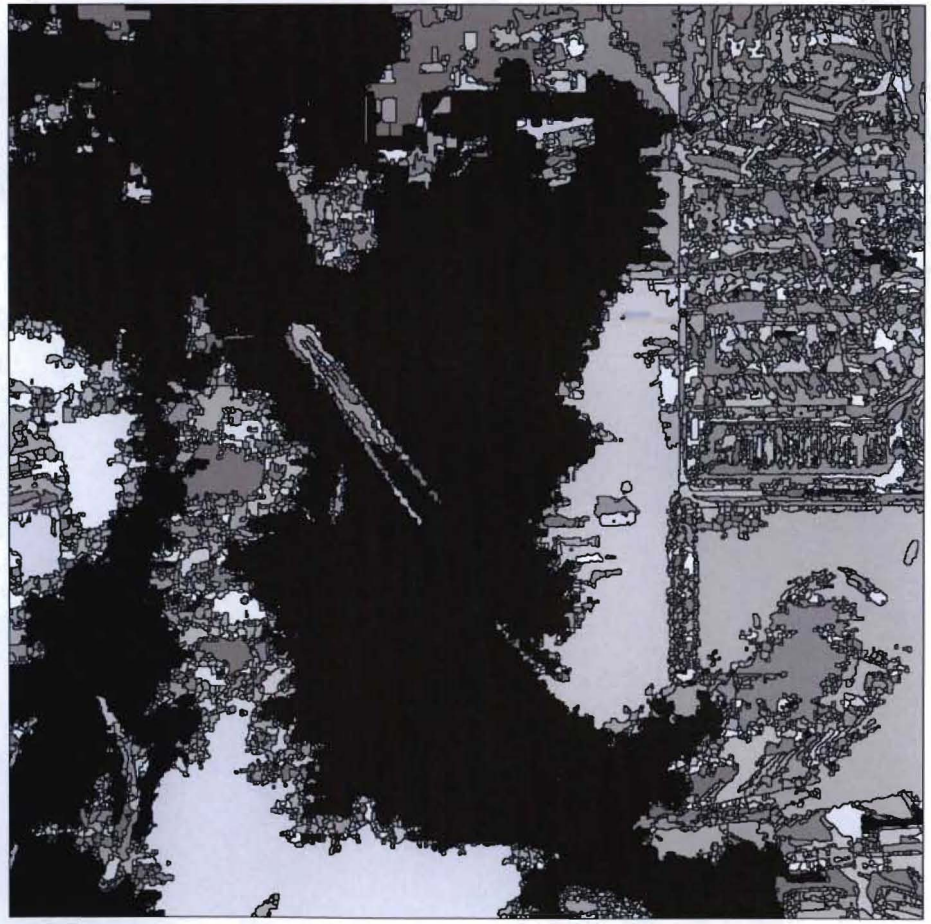


Segmented Test Images

Segmented Smoothed Image (radius = 4)

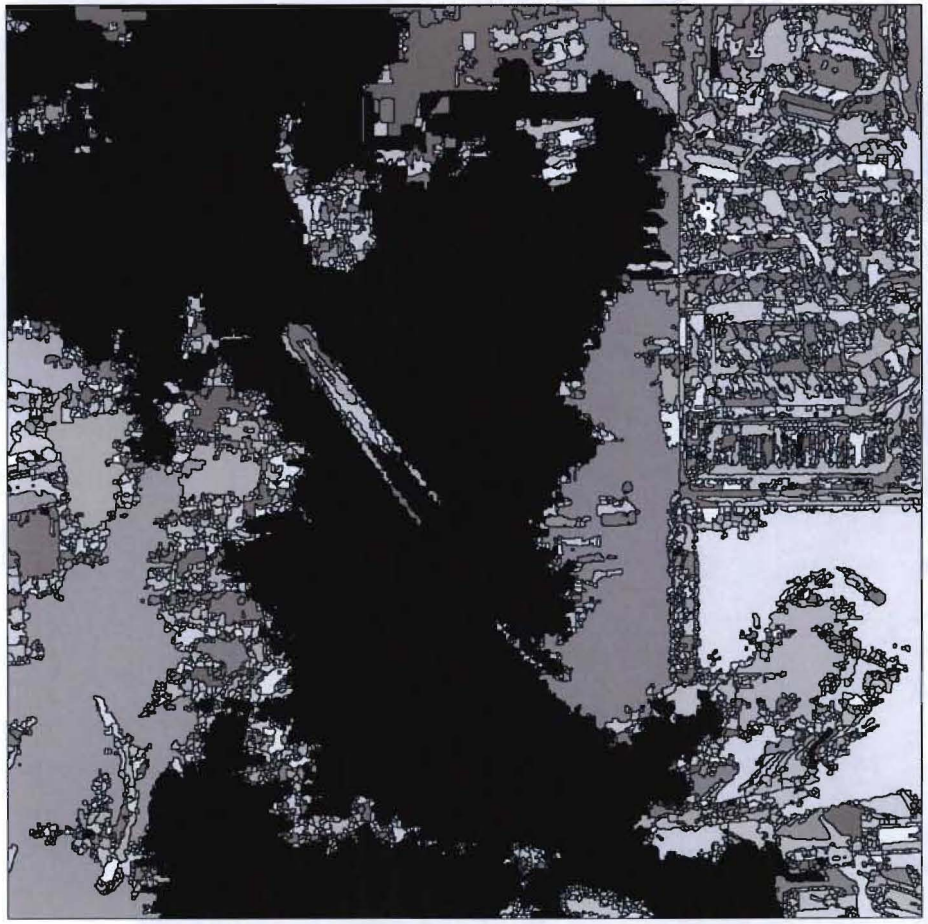


Segmented Smoothed Image (radius = 5)

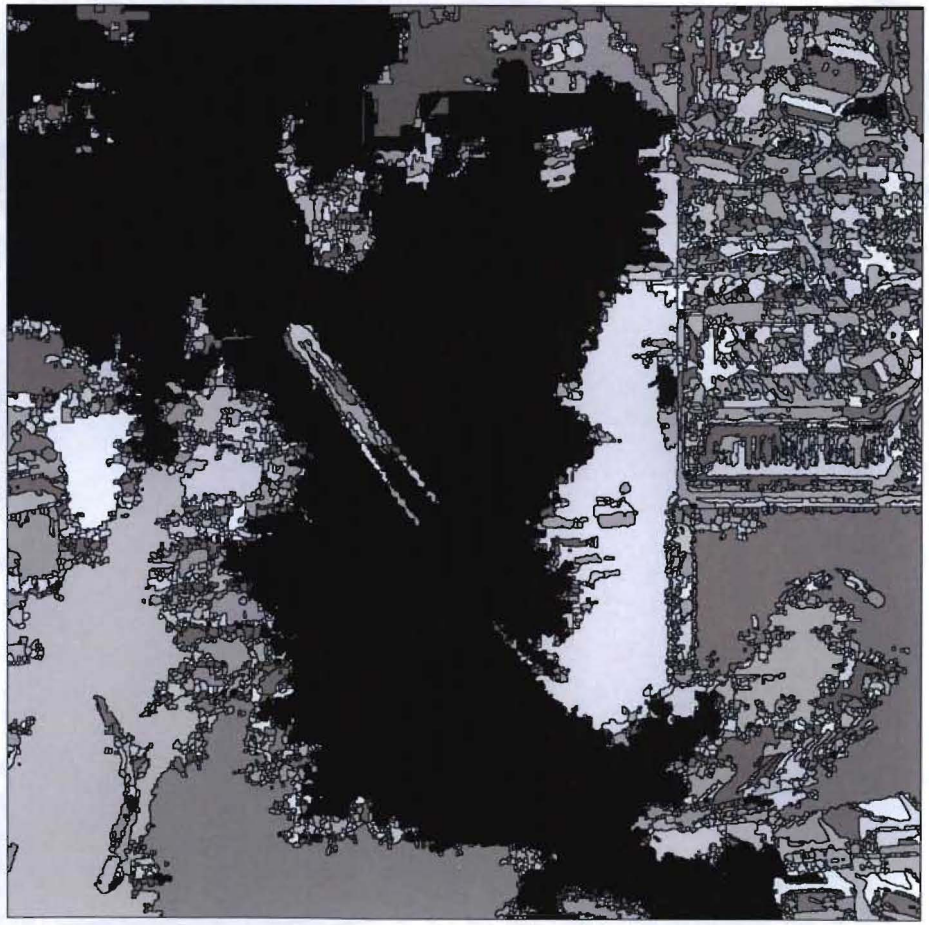


Segmented Test Images

Segmented Smoothed Image (radius = 6)

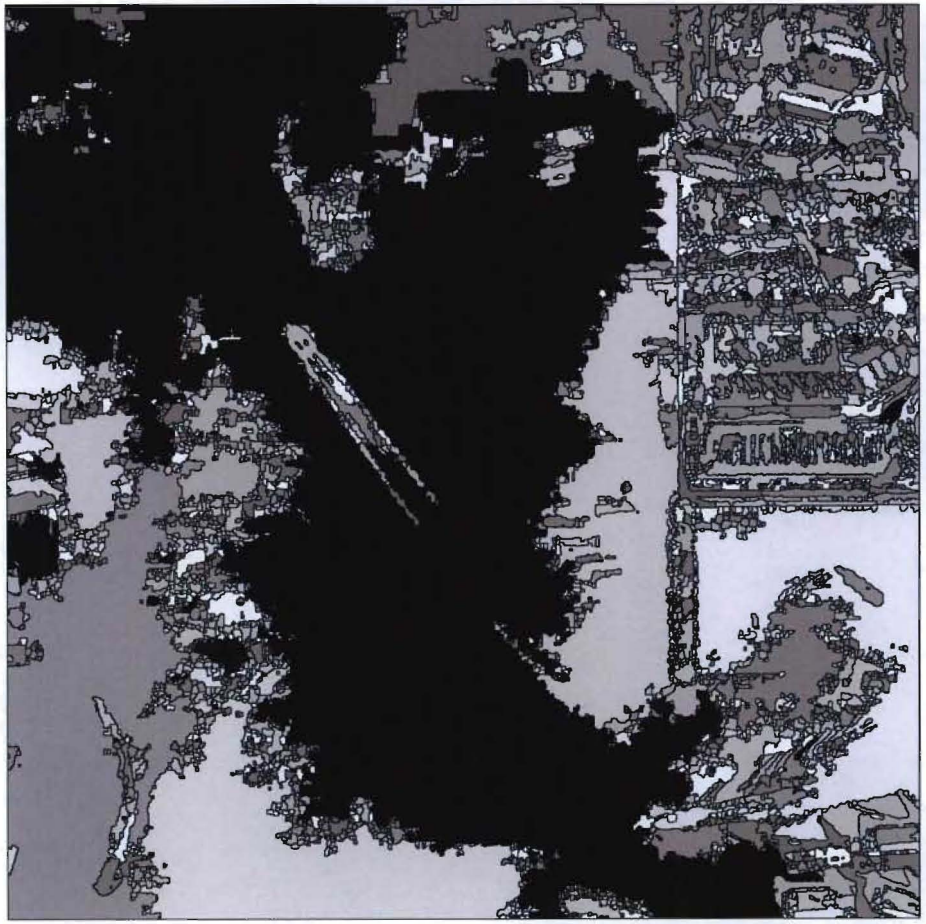


Segmented Smoothed Image (radius = 7)

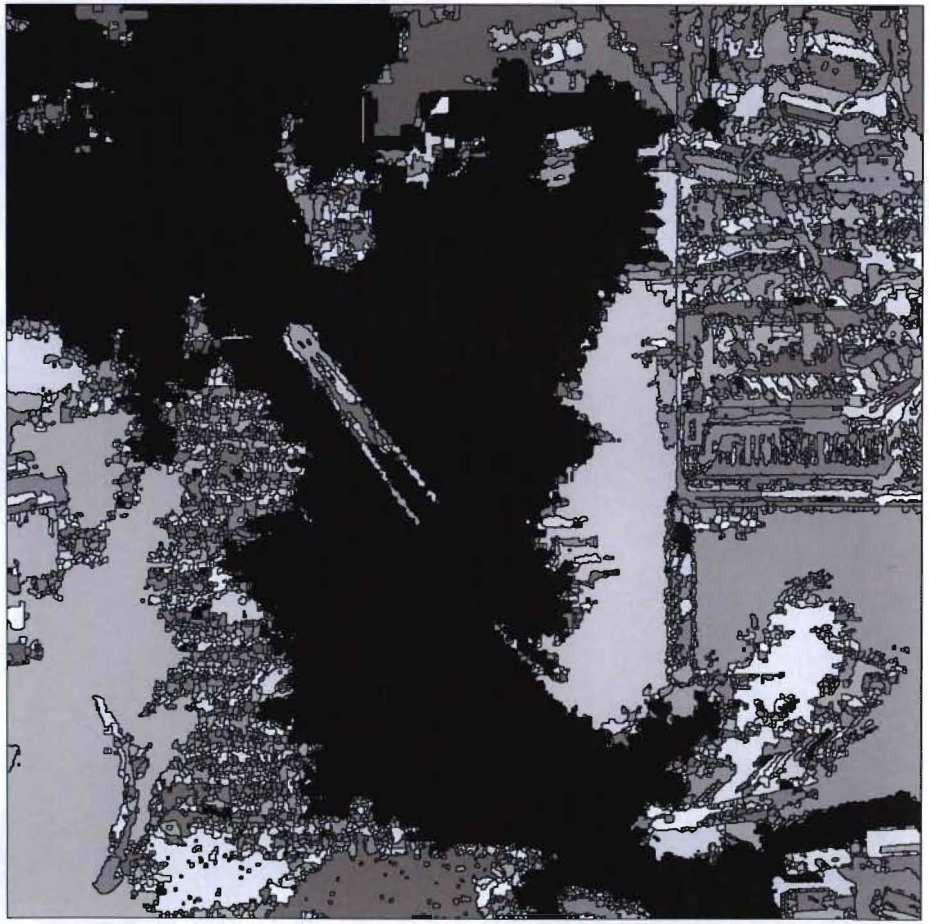


Segmented Test Images

Segmented Smoothed Image (radius = 8)

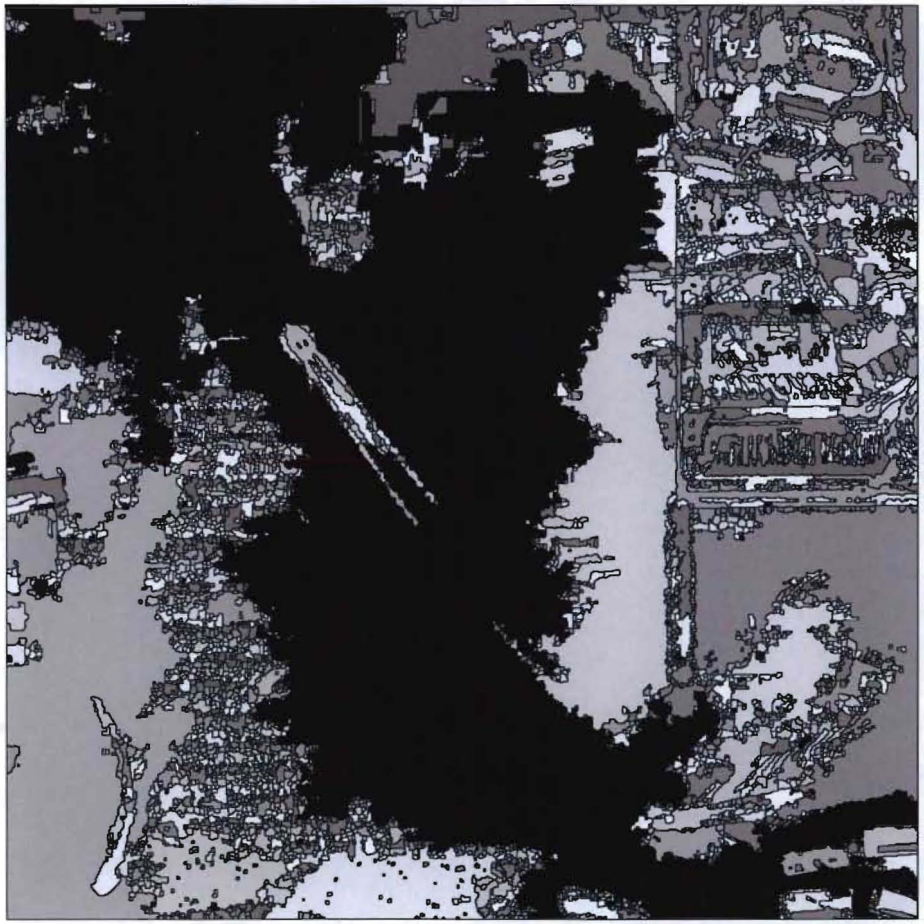


Segmented Smoothed Image (radius = 9)

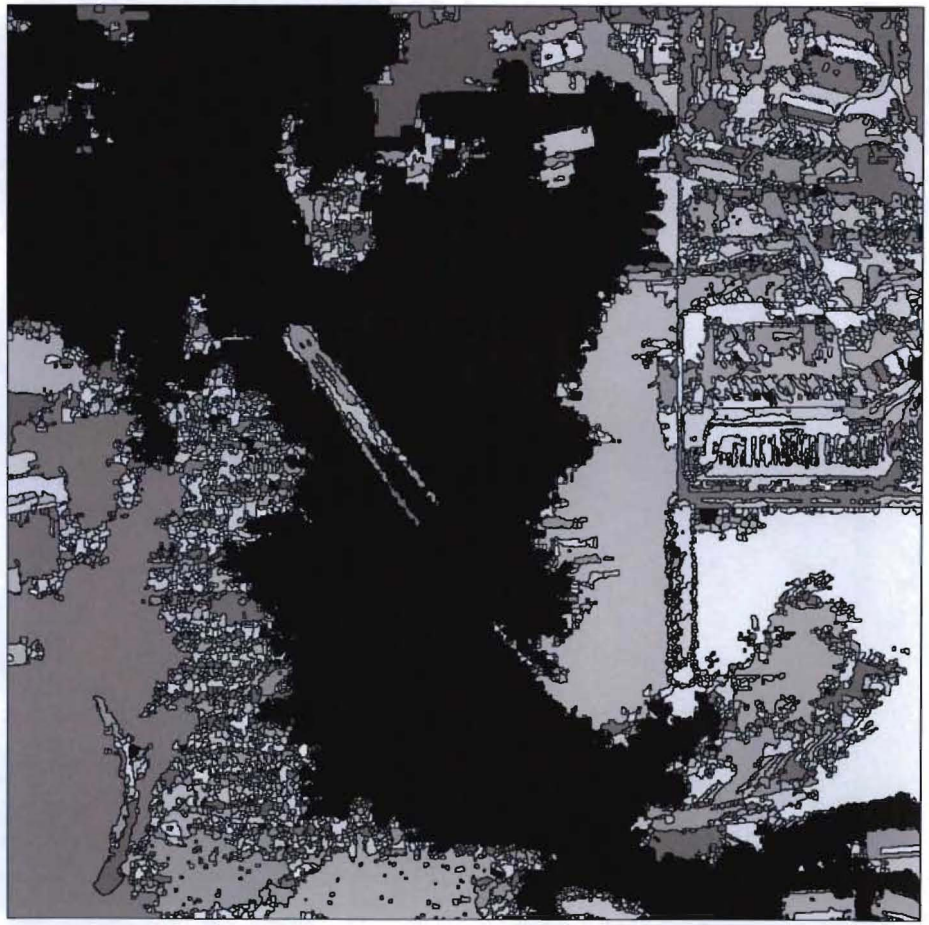


Segmented Test Images

Segmented Smoothed Image (radius = 10)

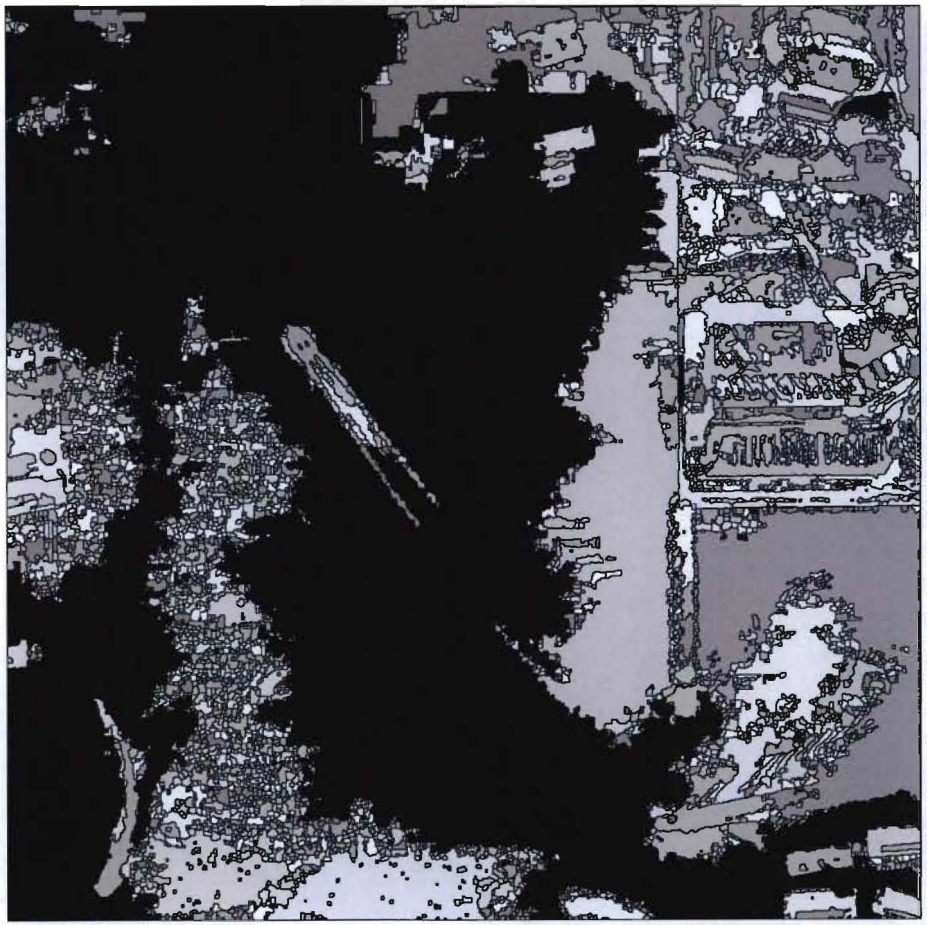


Segmented Smoothed Image (radius = 11)

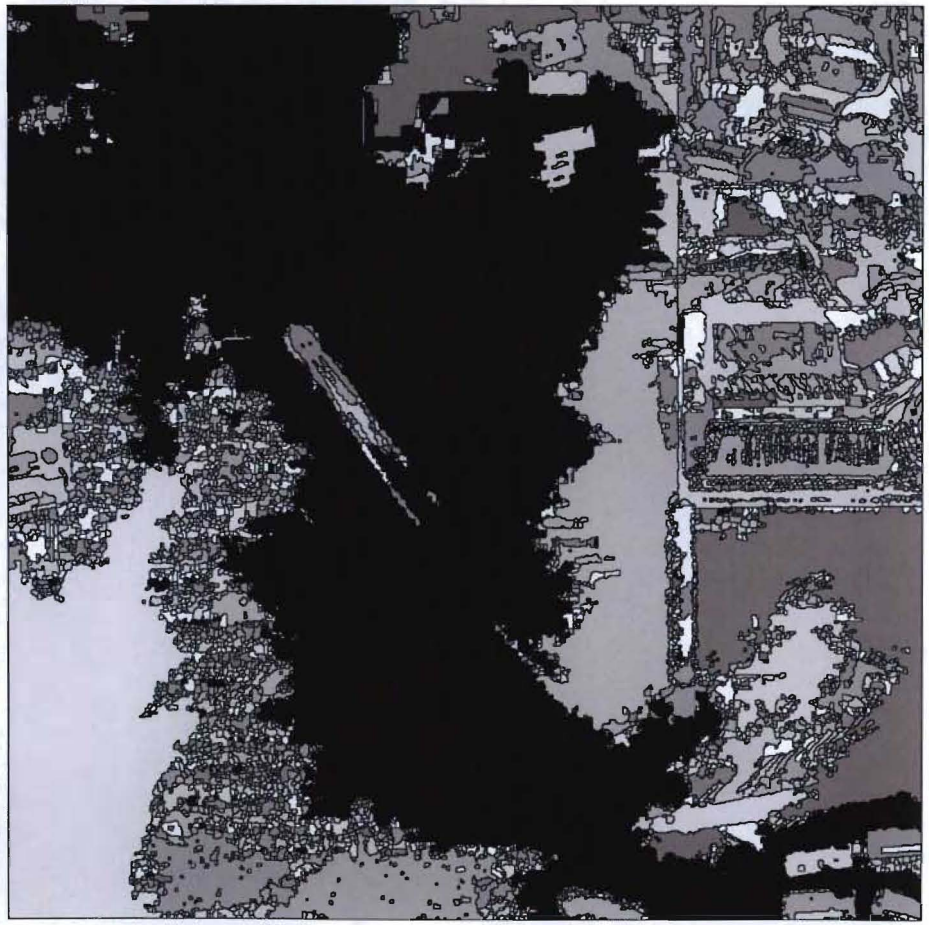


Segmented Test Images

Segmented Smoothed Image (radius = 12)



Segmented Smoothed Image (radius = 13)



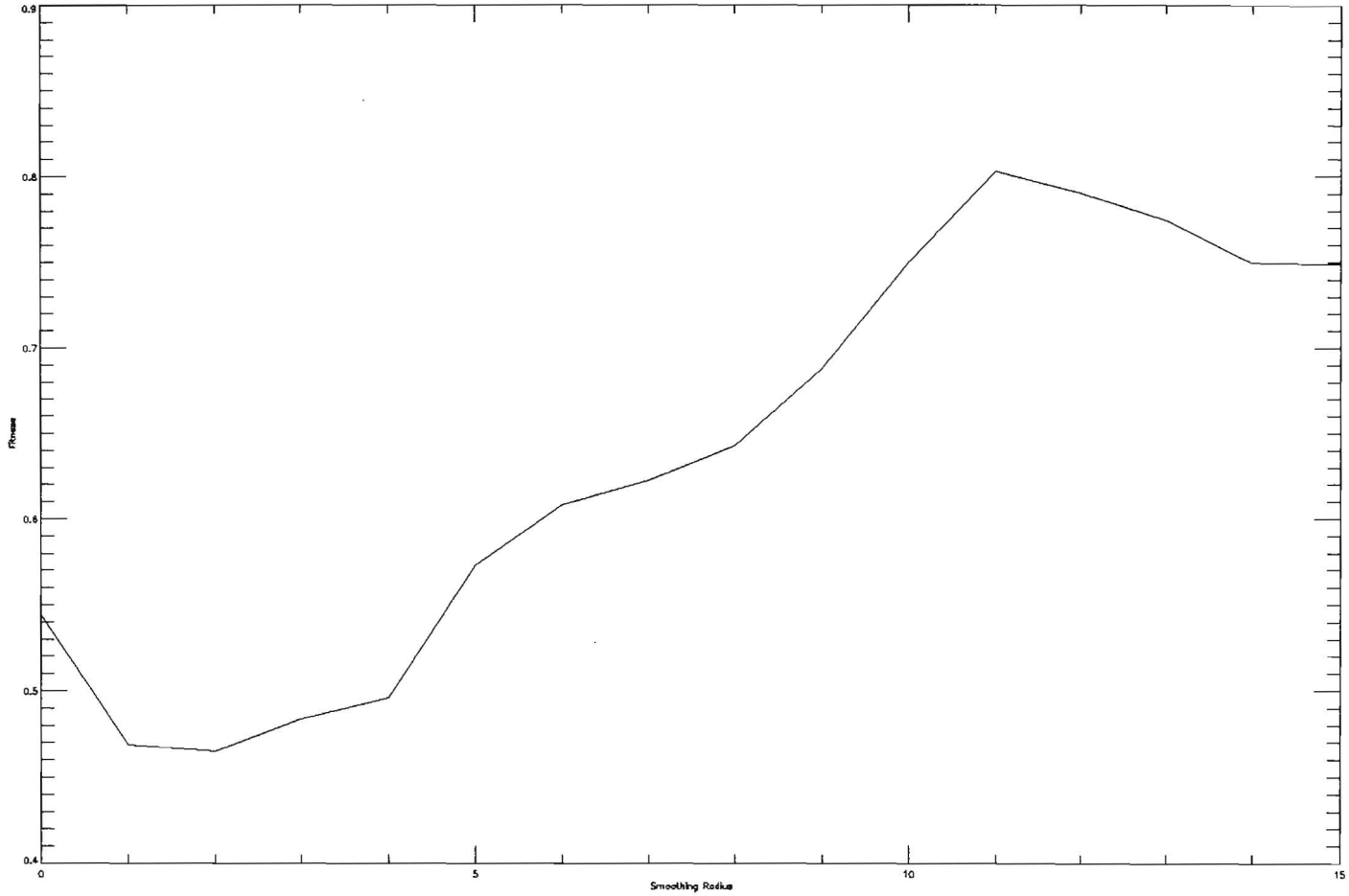
Segmented Test Images

Segmented Smoothed Image (radius = 14)

Segmented Smoothed Image (radius = 15)

Segmented Images Animation

Fitness VS Smoothing Radius



Further Work

- Make implementation of fitness calculation more efficient
  - Also, investigate/evaluate other algorithms
- Implement optimization strategy for pre-processing pipelines
  - GA, perhaps
- Decide on suite of fundamental operators (genes) for pre-processing pipelines
  - Could consider locally-adaptive filters
    - e.g. morphological amoebas
    - But need to find efficient implementations