A combinatorial method for tracing objects using semantics of their shape

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Albuquerque, New Mexico

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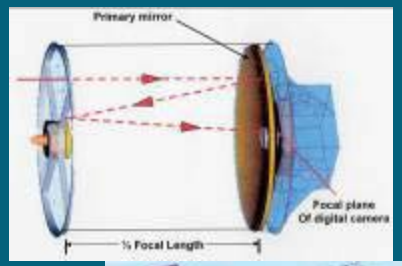
Outline

- *Intelligence challenge:* too few humans to look everywhere (Out-of-place vehicles in NGA's *Overhead Imagery Research Dataset*, OIRDS)
- *Key idea:* shape with semantics understands vehicles
- *Technical innovation and early results:* combinatorial algorithm and implementation applied to OIRDS and other images
- *Practical detail:* fit into commercial workflow (Definiens object-based image analysis)
- Algorithm drill-down, peek at code

Intelligence challenge

Kestrel Eye will be a network of 30 kg small satellites beaming images directly to troops on the ground to order. A mobile, backpack-ready ground receiver can link up with the satellites in real time, downloading two pictures a second covering five square miles in each shot. Those photos will then be stored on a central server so others operating in the area can take a look.

66 pounds



http://www.virtualacquisitionshowcase.com/docs/2007/IntelliTech-Brochure.pdf

The ten-inch telescope is not capable of the high-res imaging of some of its intelligence – and increasingly its civilian – counterparts. But a resolution of five feet over five square miles is more than enough to pick out a building, **locate an out-of-place vehicle** or capture a convoy on the move.

Too few humans to look everywhere

http://www.popsci.com/technology/article/2009-12/tiny-spy-satellites-give-troops-ground-eye-sky

Really-large haystack of digital images

sensors are *blackening sky* because humans see enough with them to revolutionize war fighting

adding automation to human workflow
is key to getting much more from these data

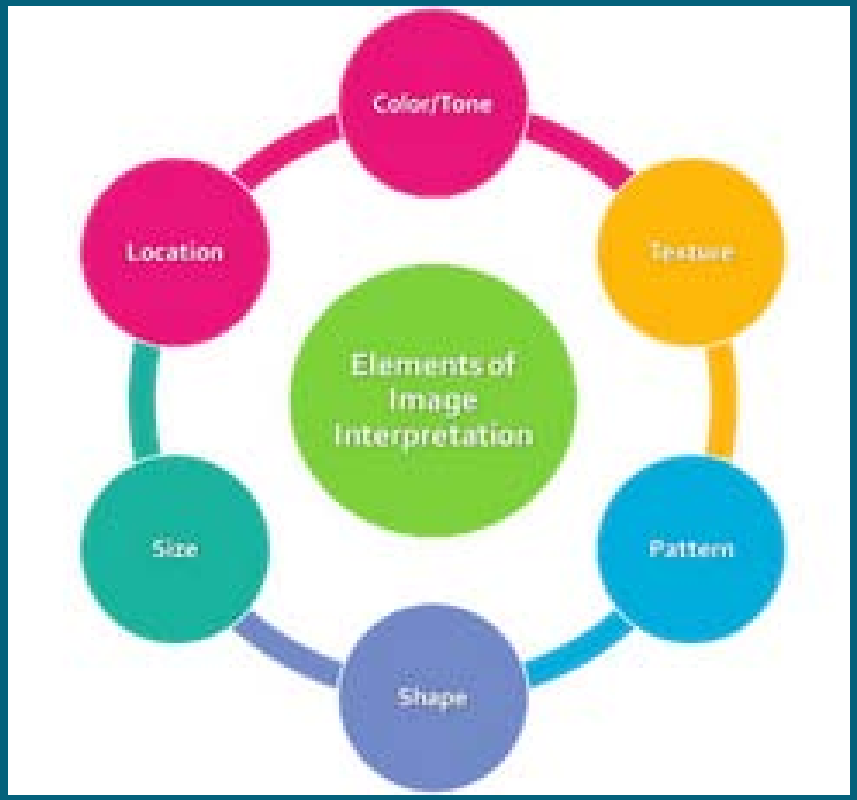
Beast of Kandahar
http://www.popsci.com/technology/article/2009-12/afghanistans-mystery-uav

Key idea:
Shape with semantics understands vehicles

There is an infinite number of uniquely shaped natural and man-made objects in the world. A few examples of shape are the triangular shape of modern jet aircraft and the shape of a common single family dwelling. Humans have modified the landscape in very interesting ways that have given shape to many objects, but nature also shapes the landscape in its own ways. In general, straight, rectilinear features in the environment are of human origin. Nature produces more subtle shapes.

http://en.wikipedia.org/wiki/Aerial_photographic_and_satellite_image_interpretation

Elements of Image Interpretation



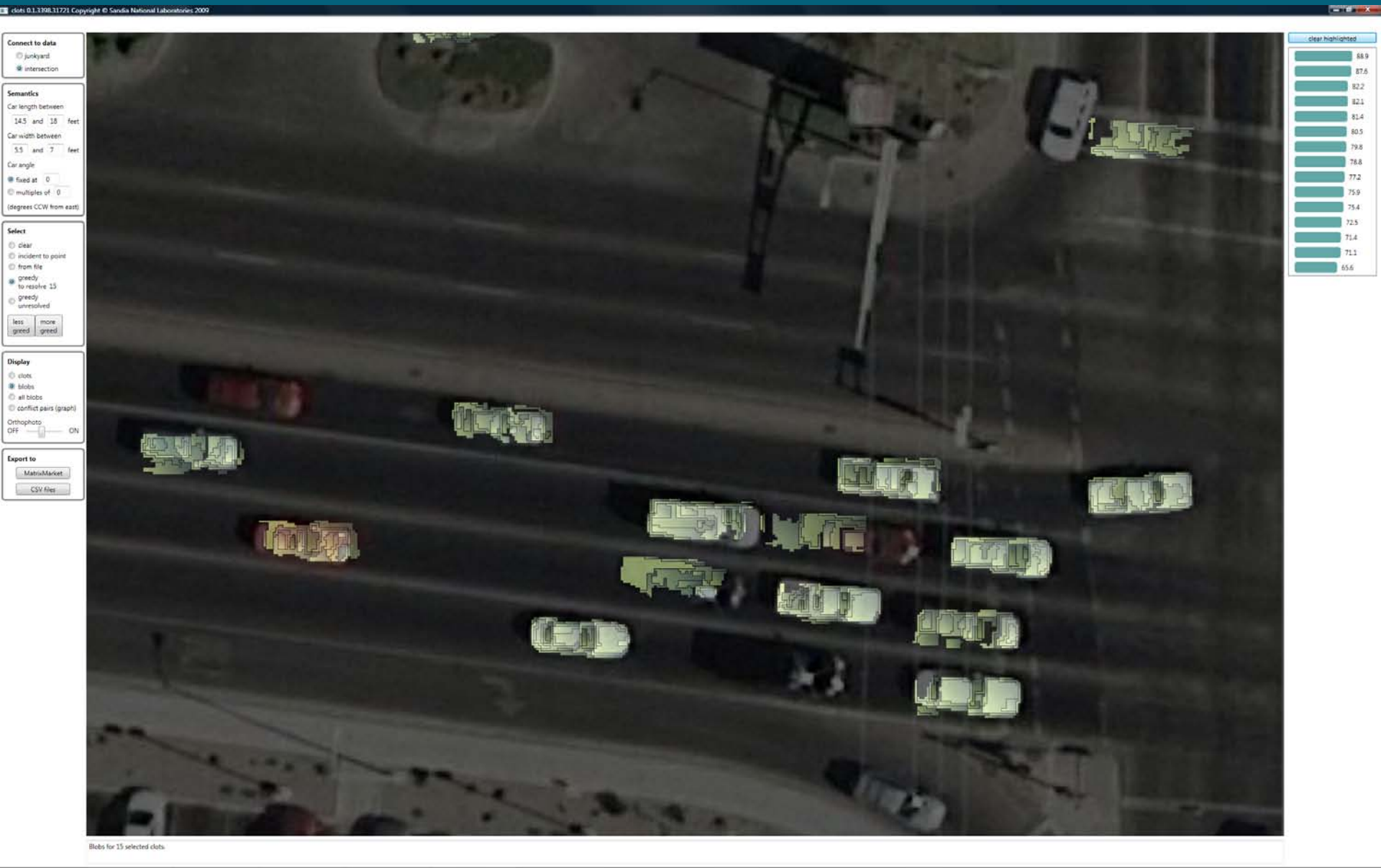
Location
Size
Shape
Shadow
Tone/Color
Texture
Pattern
Height and Depth
Site/Situation/Association

http://letters-sal.blogspot.com/2009/03/elements-of-image-interpretation.html

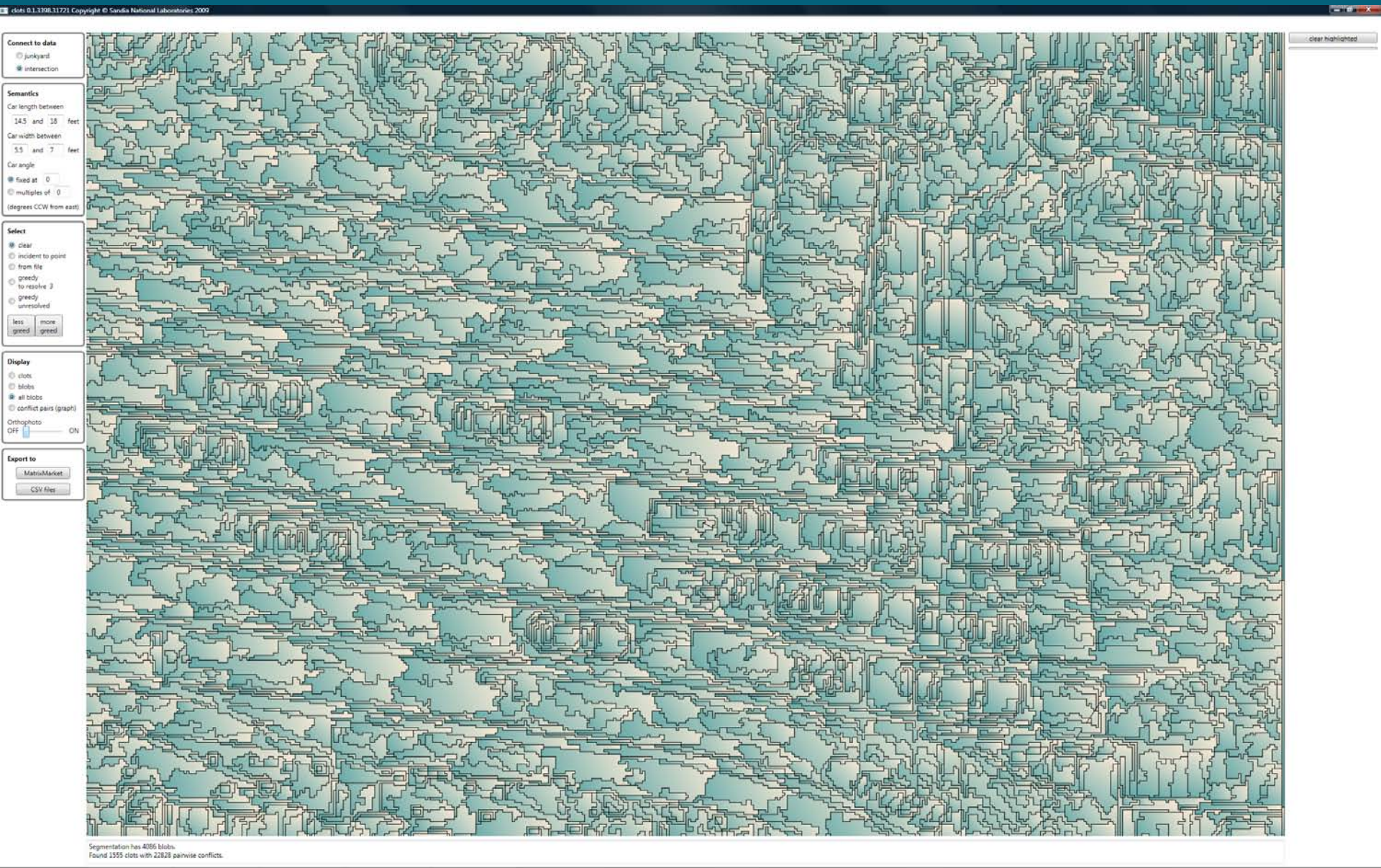
http://en.wikipedia.org/wiki/Aerial_photographic_and_satellite_image_interpretation

At core of Definiens eCognition is finding blobs of similar pixels

Our combinatorial algorithm finds car-shaped blob subsets



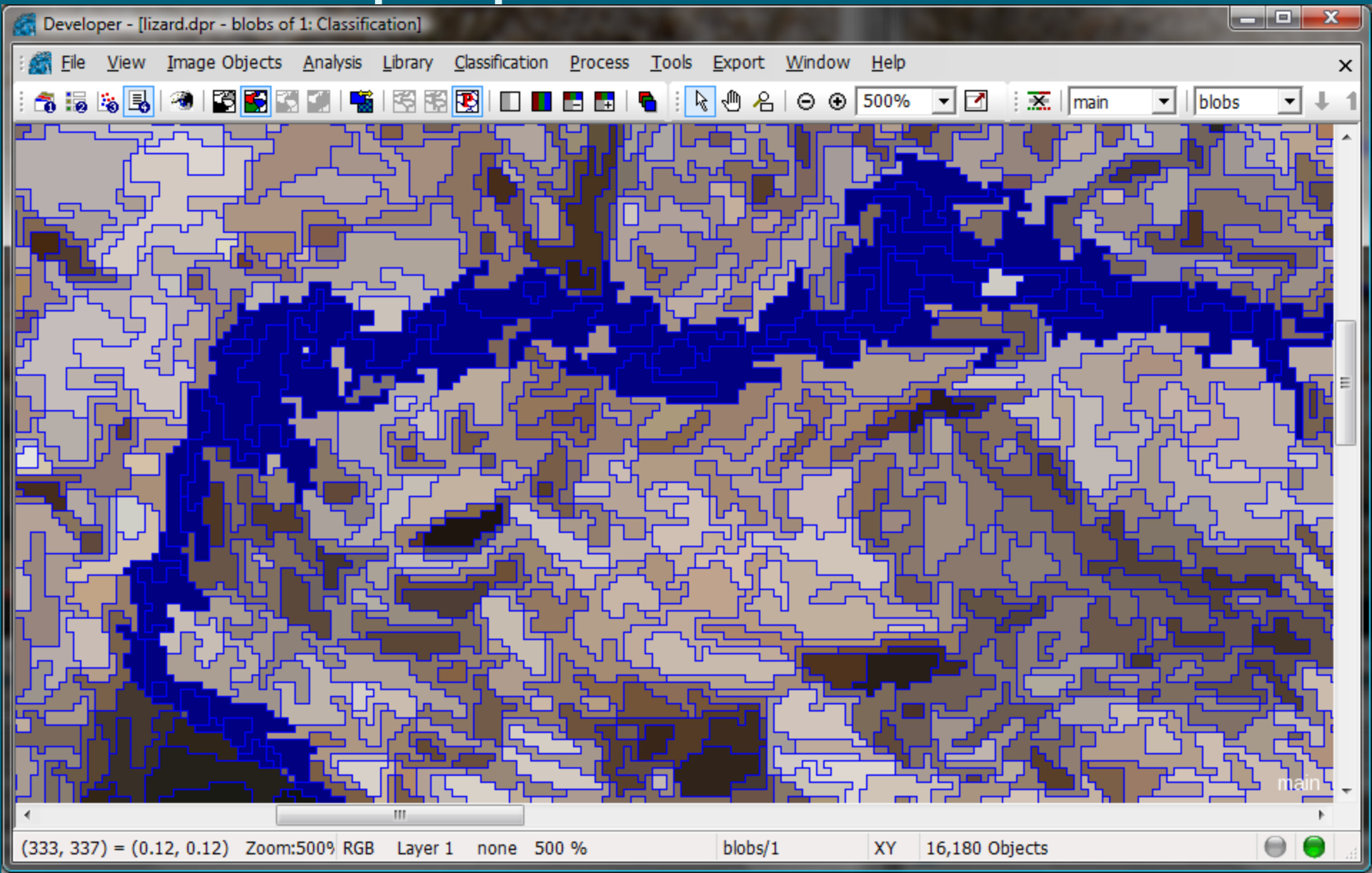
using only shape information (no peeking at pixel values)



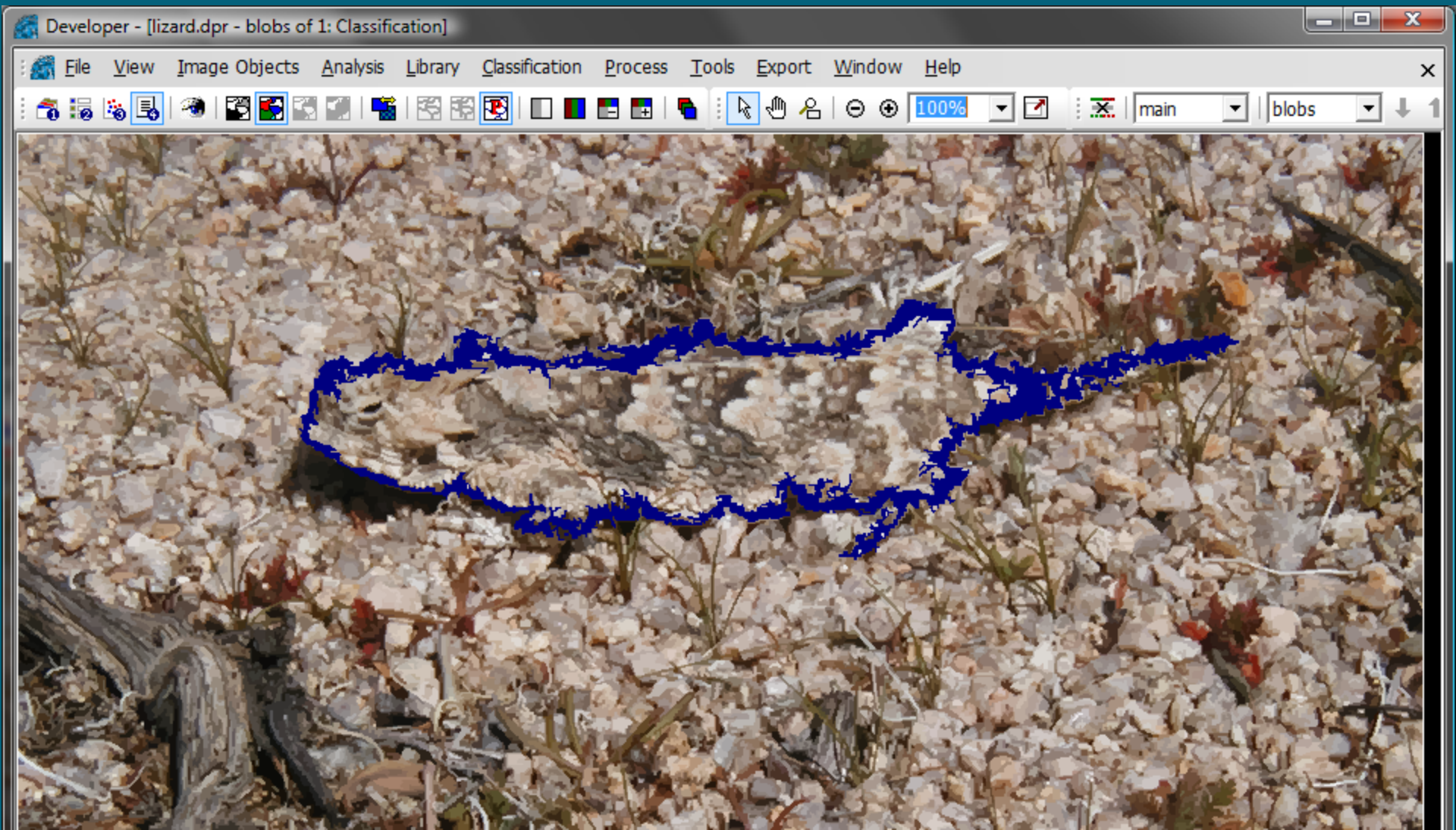
Find combination of image blobs that comprises lizard

Charless Fowlkes from UC Irvine, *Learning models of boundaries in natural images*, talk at Sandia National Laboratories, 11-5-2009.

General-purpose tool finds blobs



Manual blob selection



Assist human by applying rule: surrounded by lizard => lizard

lizard vs. car

Lizard semantics

- Complicated, possibly build in terms of component parts (eye, legs, tail)

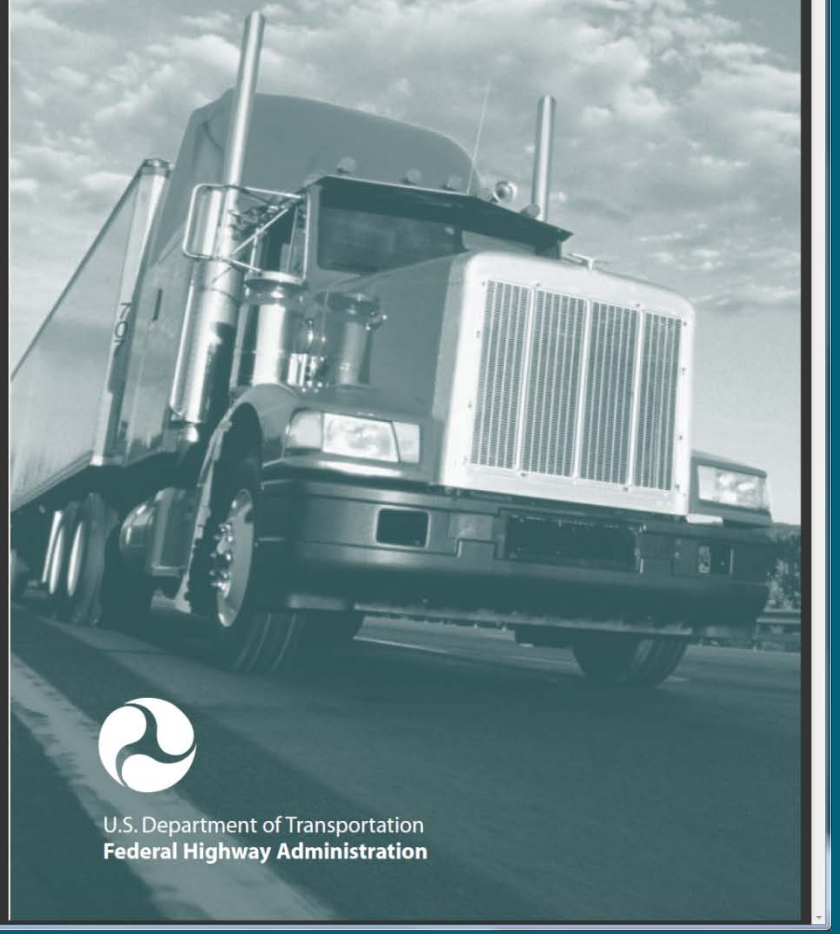
Car semantics (for appearce in orthophoto)

- Rectangular shape where width and height are in known range
- Satisfy car exclusion principle

dot_vehicle_size_regulations.pdf - Adobe Acrobat Pro

File Edit View Document Comments Forms Tools Advanced Window Help

Federal Size Regulations for Commercial Motor Vehicles



U.S. Department of Transportation
Federal Highway Administration

dot_vehicle_size_diagram.pdf - Adobe Acrobat Pro

File Edit View Document Comments Forms Tools Advanced Window Help

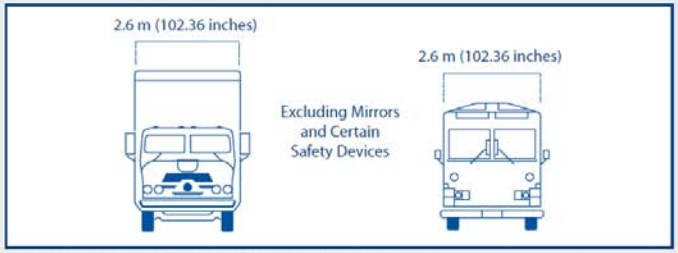


Figure 1. Commercial Motor Vehicle Width Limits

102 inches wide (i.e. non-special mobile equipment) to operate on the NN, then States must issue special overwidth permits.

LENGTH REQUIREMENTS

The Federal length limits are principally minimums that States must allow for the following vehicles on the NN and reasonable access routes.

Truck Tractor-Semitrailer Combinations

The minimum allowable length limit for the semitrailer in this combination is 14.63 m (48 feet) or the grandfathered limit for a particular State. (See discussion of Grandfathered Semitrailer Lengths on page 3.) A State may not impose an overall vehicle length limit on a truck tractor-semitrailer combination operating on the NN or reasonable access routes, even if the trailer is longer than the minimum length required by Federal law (Figure 2). A State may not impose an overall length limit on a truck tractor pulling a single semitrailer or a limit on the distance between the axles of such a truck tractor.

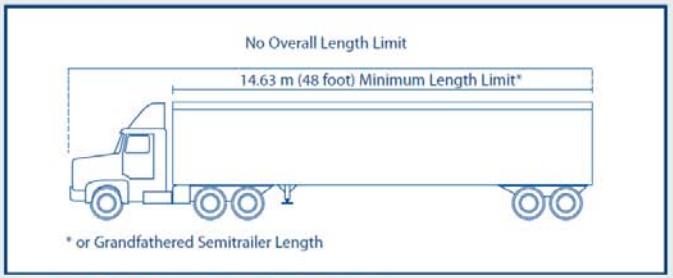


Figure 2. Truck Tractor-Semitrailer Combination

From: wstein@psl.nmsu.edu [mailto:wstein@psl.nmsu.edu]
Sent: Friday, December 18, 2009 9:13 AM
To: Diegert, Carl F
Subject: Source Forge Information

Carl – I enjoyed participating in the review of the SNL project. Here is the link to the information on the annotated imagery created by a contractor for NGA. There are about 1,000 images with about 1800 or more targets. Each image has 30 annotations and statistics. It emphasizes how users annotate images, examining background biases and a way to test computer vision algorithms. I know most contain images of vehicles (cars, pickups, etc.).
http://sourceforge.net/apps/mediawiki/oirds/index.php?title=Main_Page
Bill

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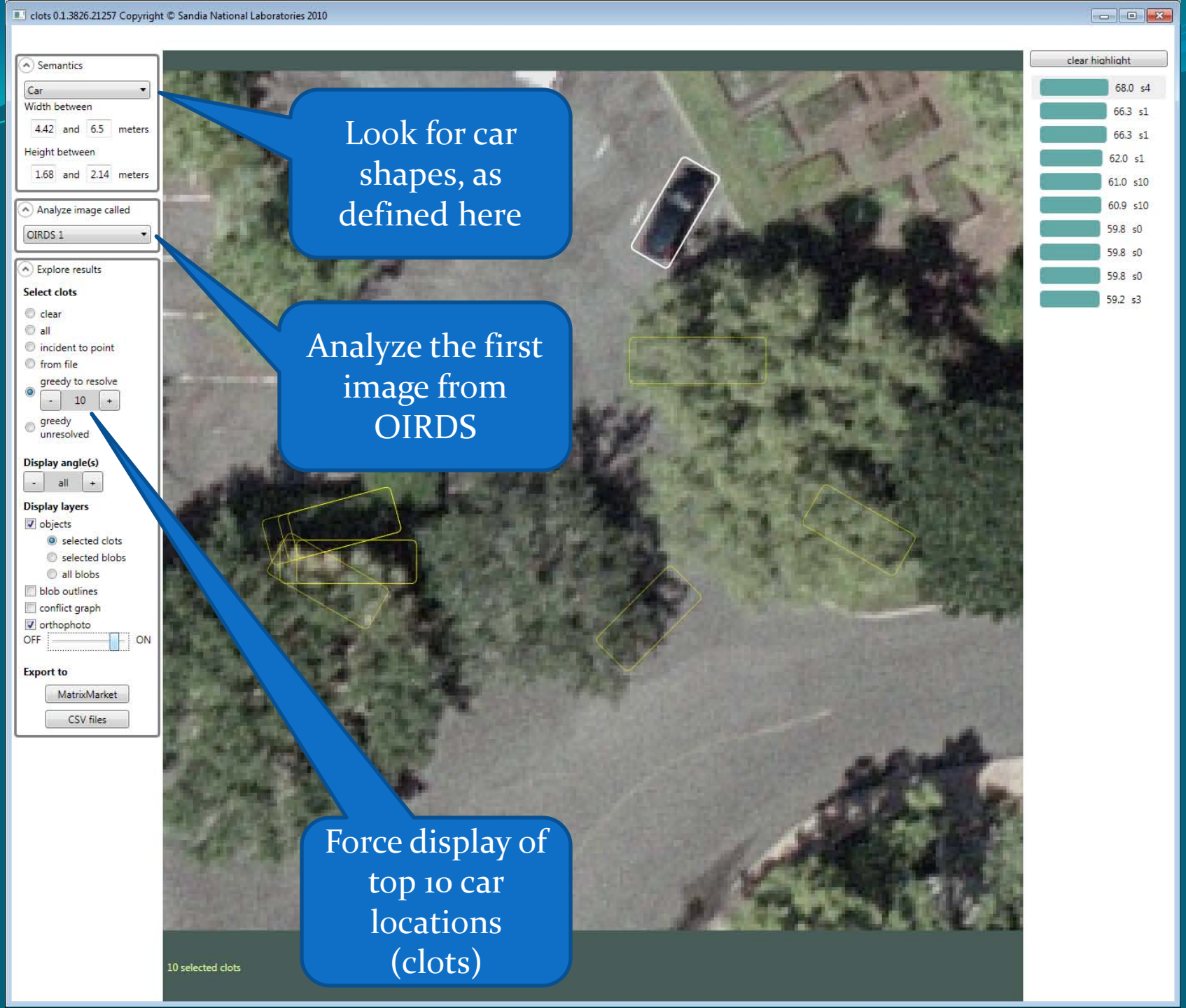
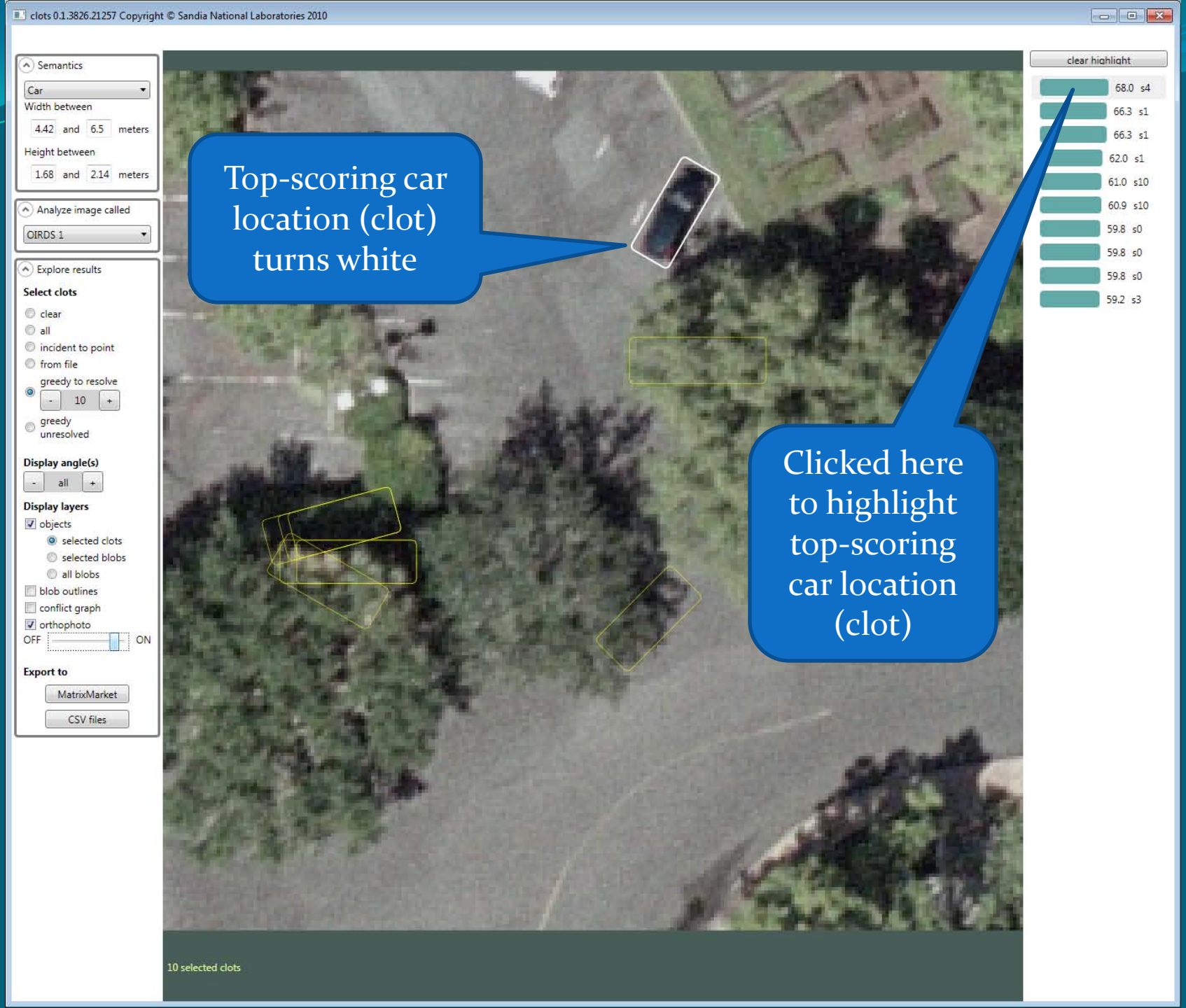
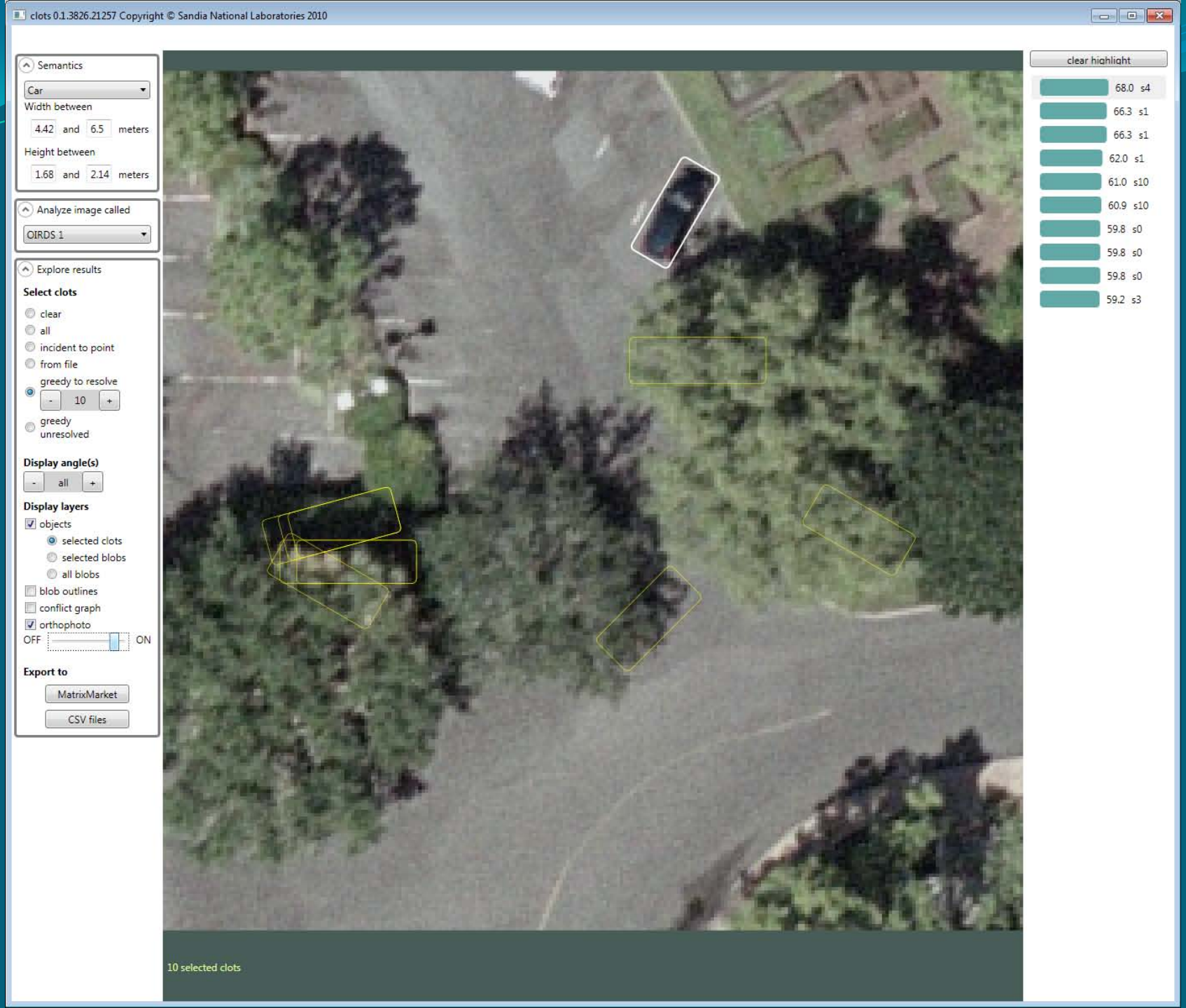
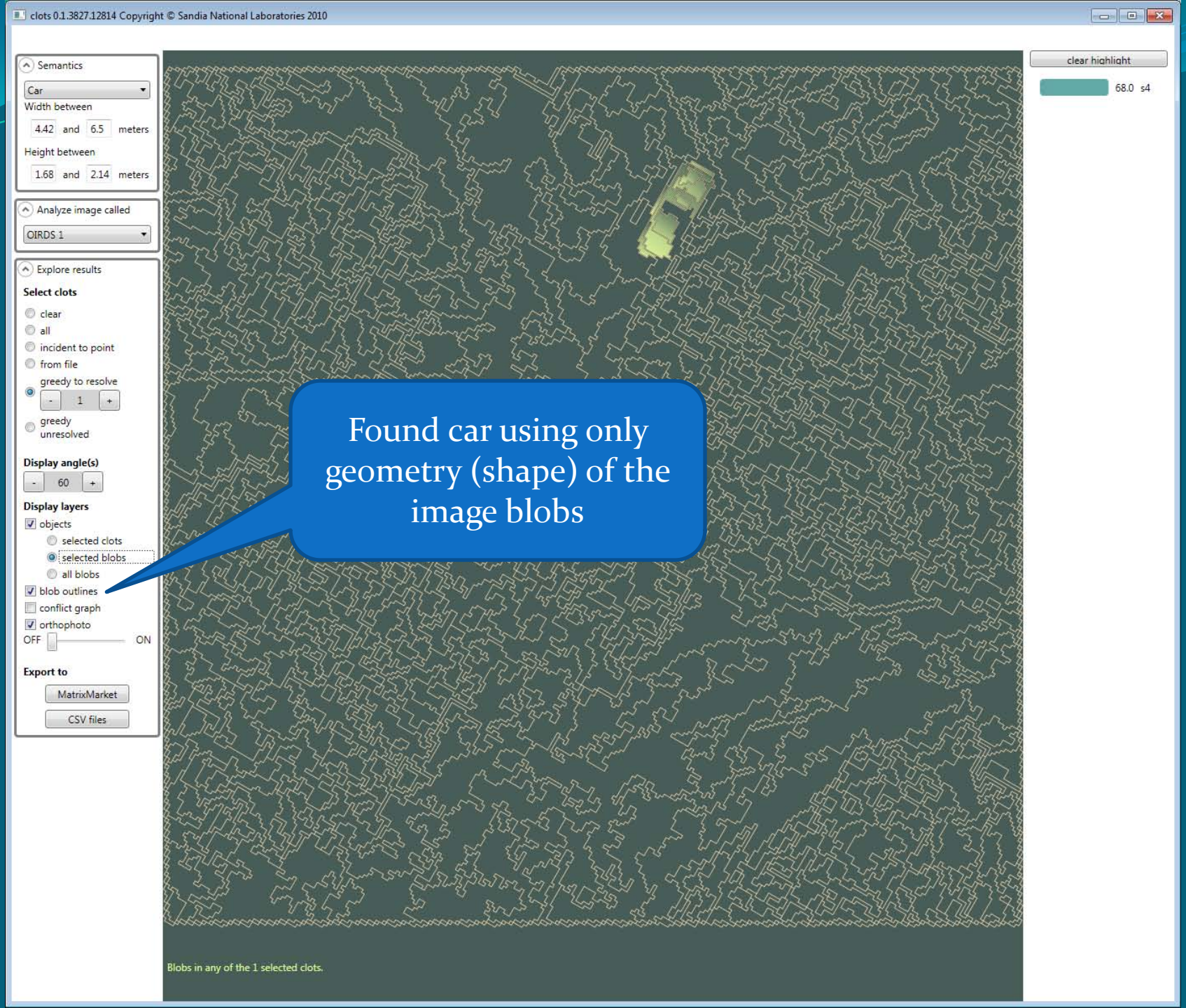
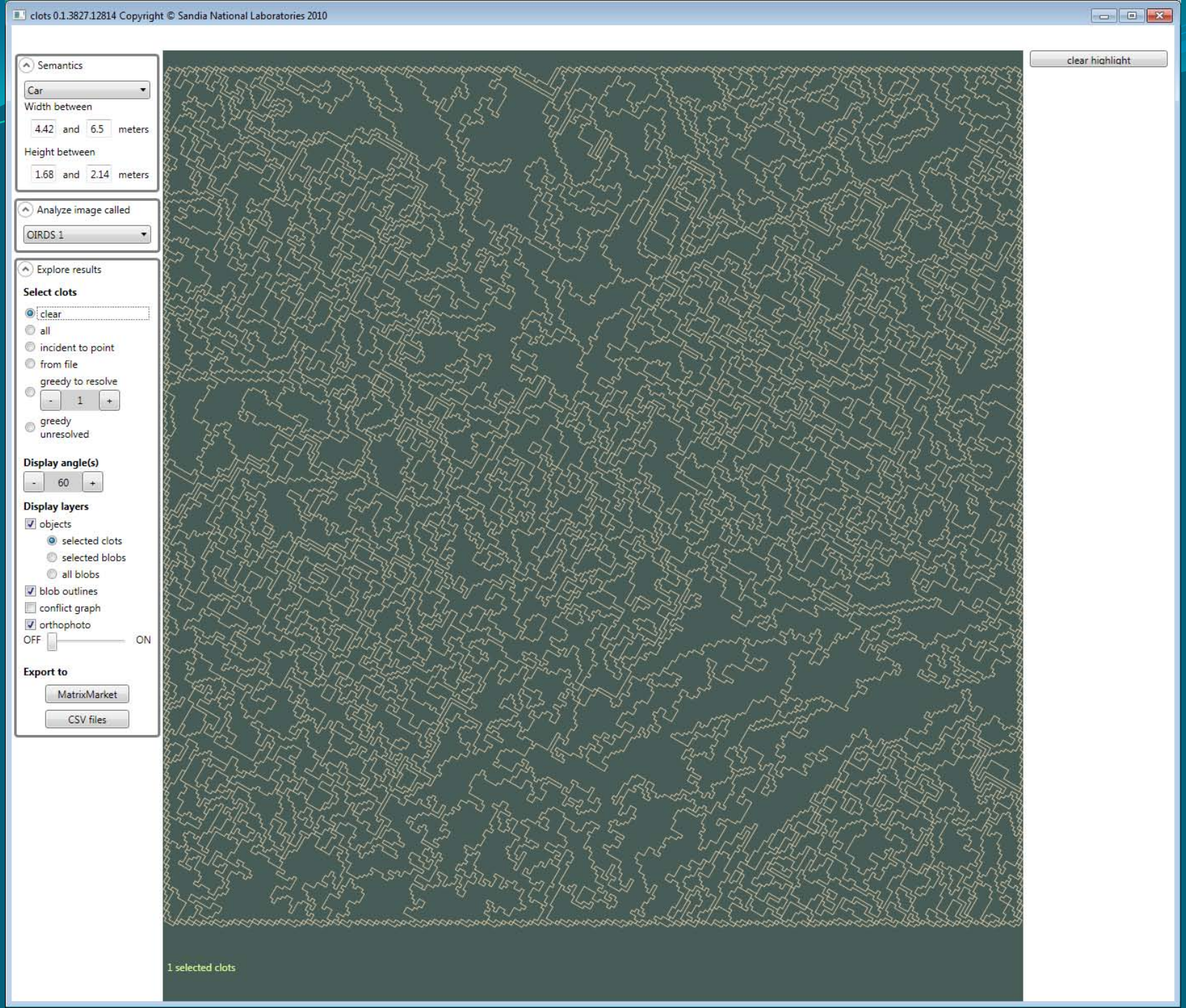

clots 0.1.3826.21257 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 1
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
10
greedy unresolved
Display angle(s)
all
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
clear highlight
68.0 s4
66.3 s1
66.3 s1
62.0 s1
61.0 s10
60.9 s10
59.8 s0
59.8 s0
59.8 s0
59.2 s3
10 selected clots
Look for car shapes, as defined here
Analyze the first image from OIRDS
Force display of top 10 car locations (clots)


clots 0.1.3826.21257 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 1
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
10
greedy unresolved
Display angle(s)
all
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
Top-scoring car location (clot) turns white
Clicked here to highlight top-scoring car location (clot)
clear highlight
68.0 s4
66.3 s1
66.3 s1
62.0 s1
61.0 s10
60.9 s10
59.8 s0
59.8 s0
59.8 s0
59.2 s3
10 selected clots


clots 0.1.3826.21257 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 1
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
- 10 +
greedy unresolved
Display angle(s)
- all +
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF ON
Export to
MatrixMarket
CSV files
10 selected clots
clear highlight
68.0 s4
66.3 s1
66.3 s1
62.0 s1
61.0 s10
60.9 s10
59.8 s0
59.8 s0
59.8 s0
59.2 s3

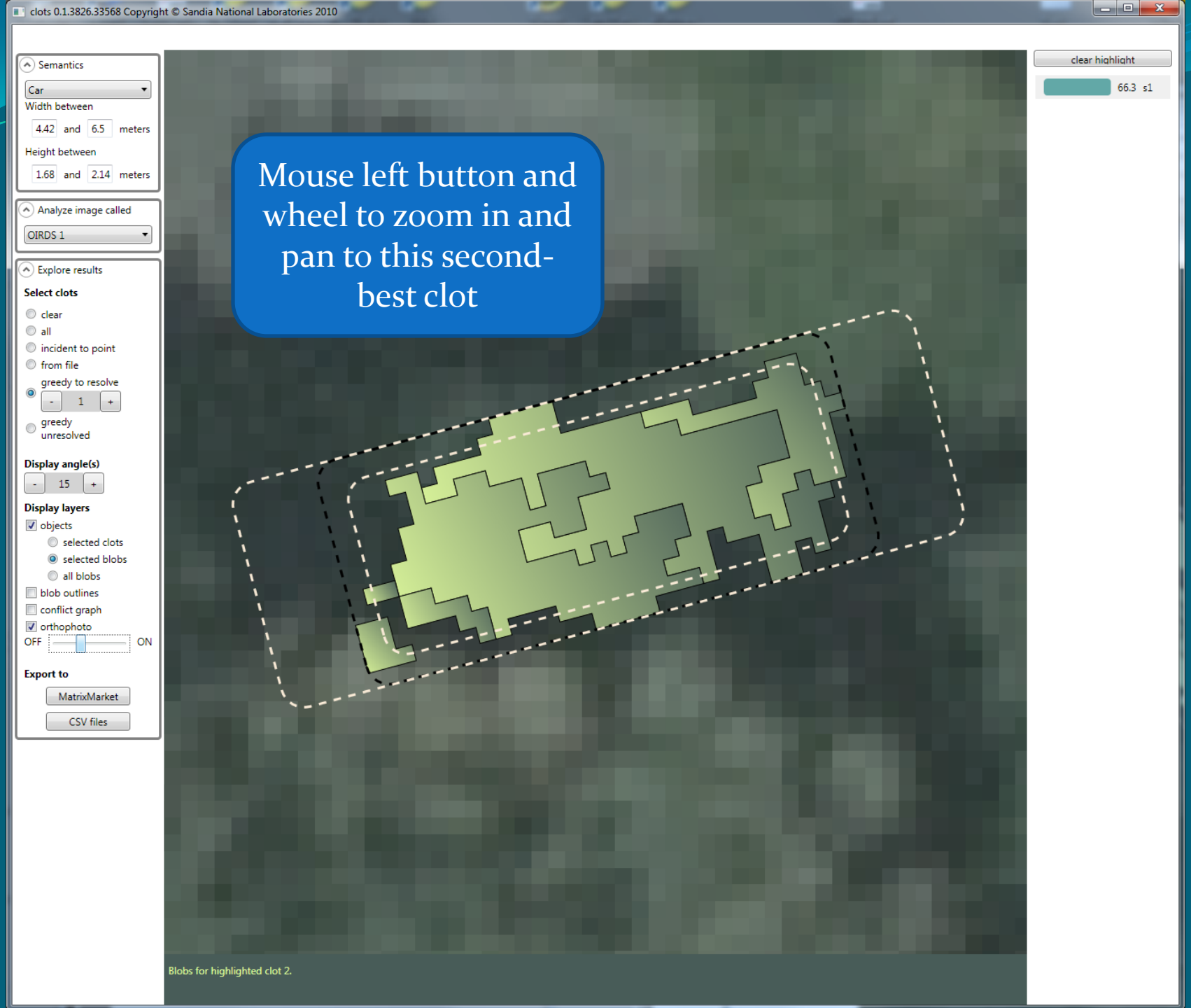


Found car using only geometry (shape) of the image blobs

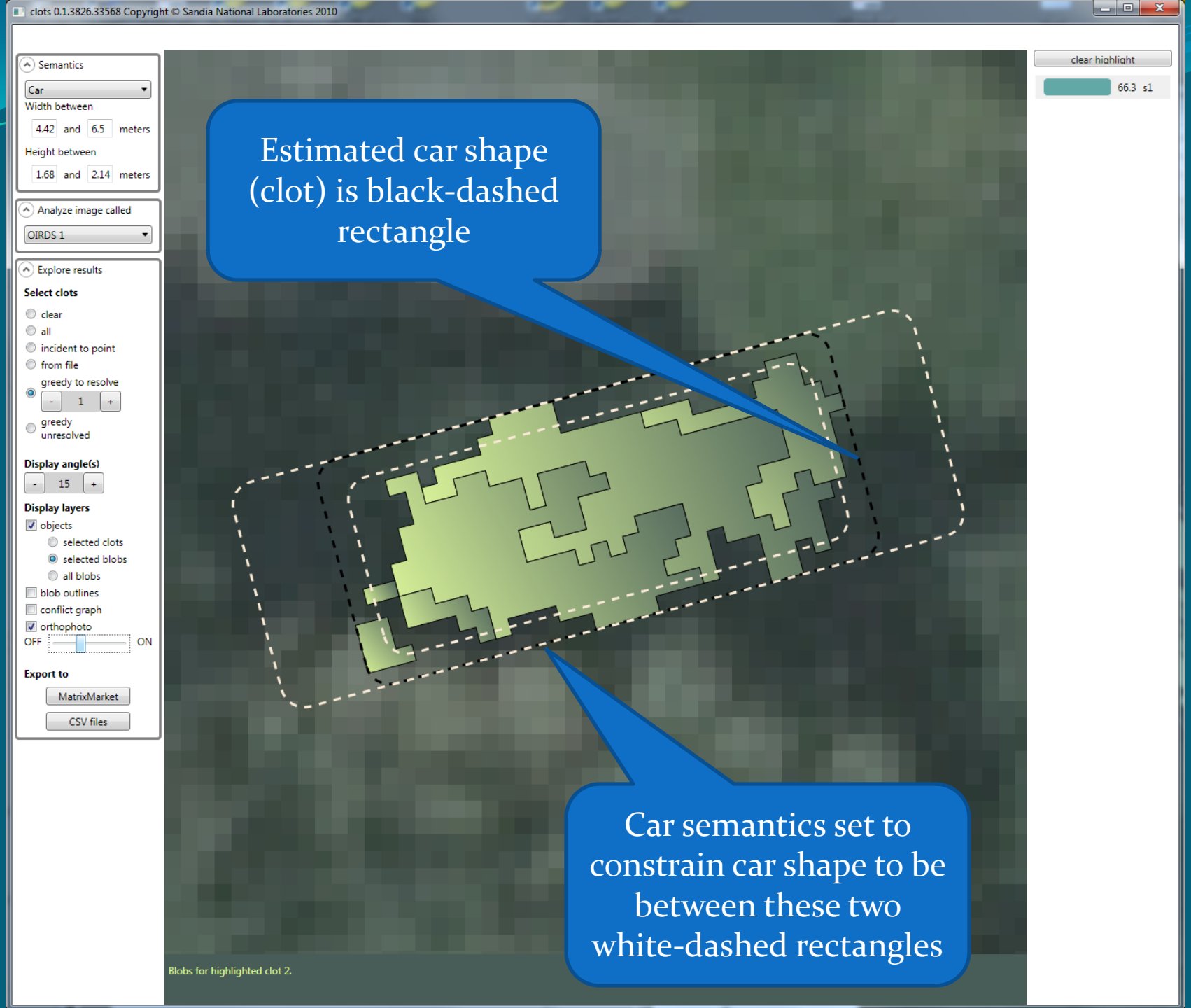

clots 0.1.3827.12814 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 1
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
- 1 +
greedy unresolved
Display angle(s)
- 60 +
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
clear highlight
1 selected clots

Click to display all clots with a score of at least 50.

clots 0.1.3826.21257 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 1
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
10
greedy unresolved
Display angle(s)
all
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
clear highlight
68.0 s4
66.3 s1
62.0 s1
61.0 s10
60.9 s10
60.0 s10
59.8 s0
59.8 s0
59.2 s3
59.2 s3
59.1 s4
58.9 s0
58.9 s0
57.1 s4
57.0 s4
57.0 s4
56.9 s5
56.8 s9
56.6 s10
56.0 s5
56.0 s5
55.9 s1
55.7 s3
55.3 s1
54.5 s6
54.5 s0
54.5 s0
54.4 s10
54.4 s0
53.8 s0
53.6 s0
53.6 s5
53.5 s4
53.4 s1
53.3 s6
53.3 s2
53.1 s5
52.7 s0
52.6 s8
Click to highlight second-best scoring clot
Click to display blobs that comprise highlighted clot
Blobs for highlighted clot 2.

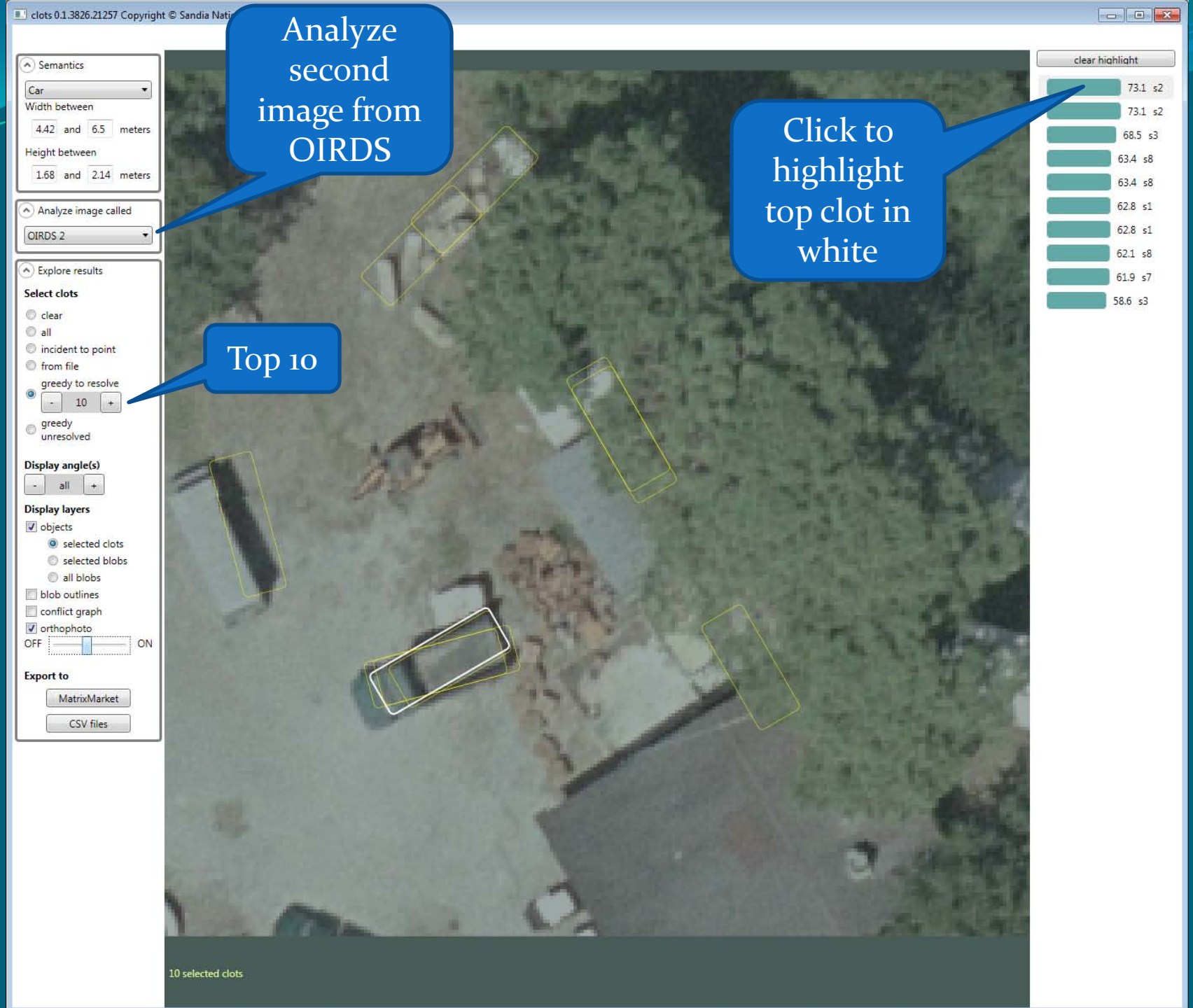


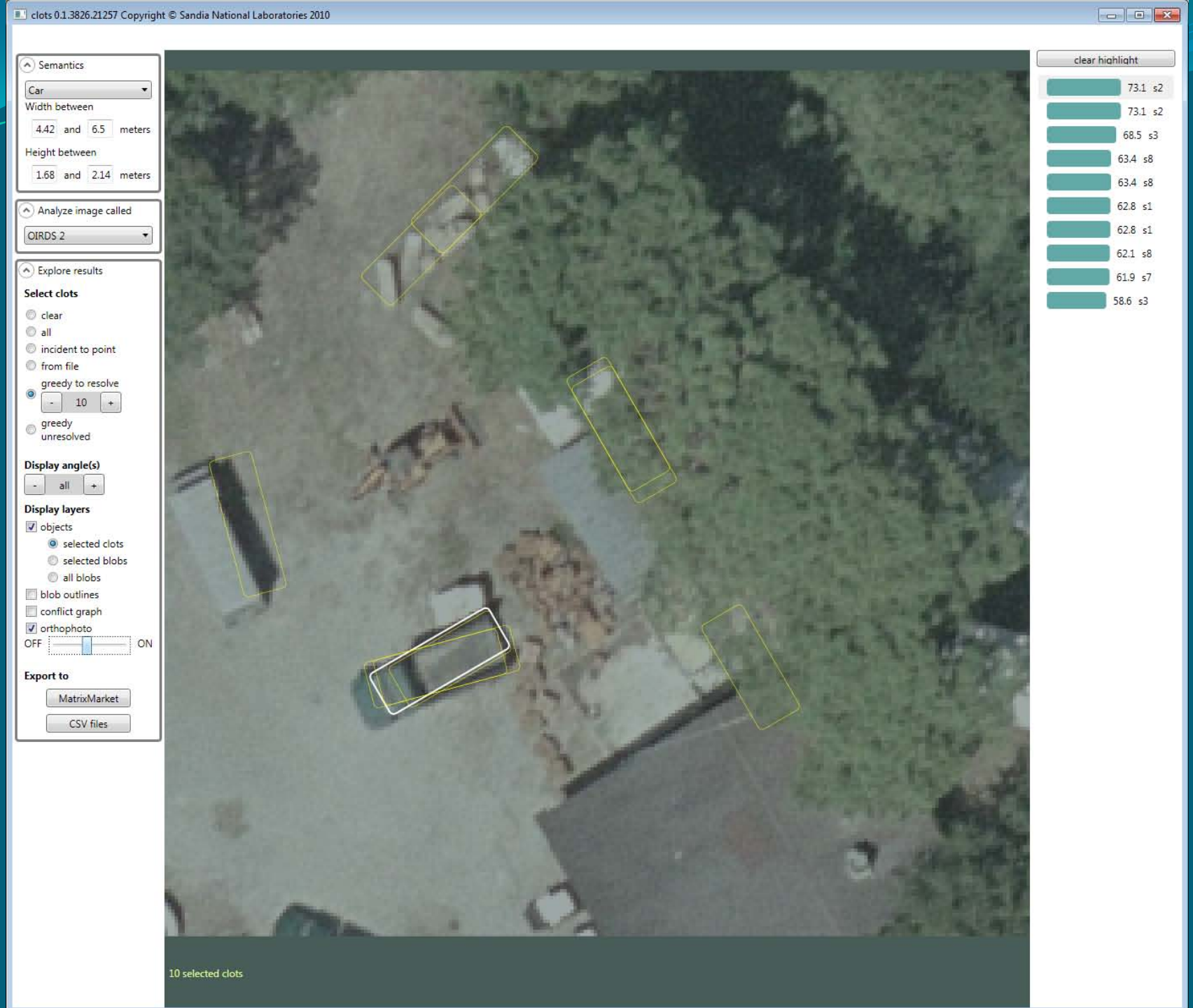
Mouse left button and wheel to zoom in and pan to this second-best clot

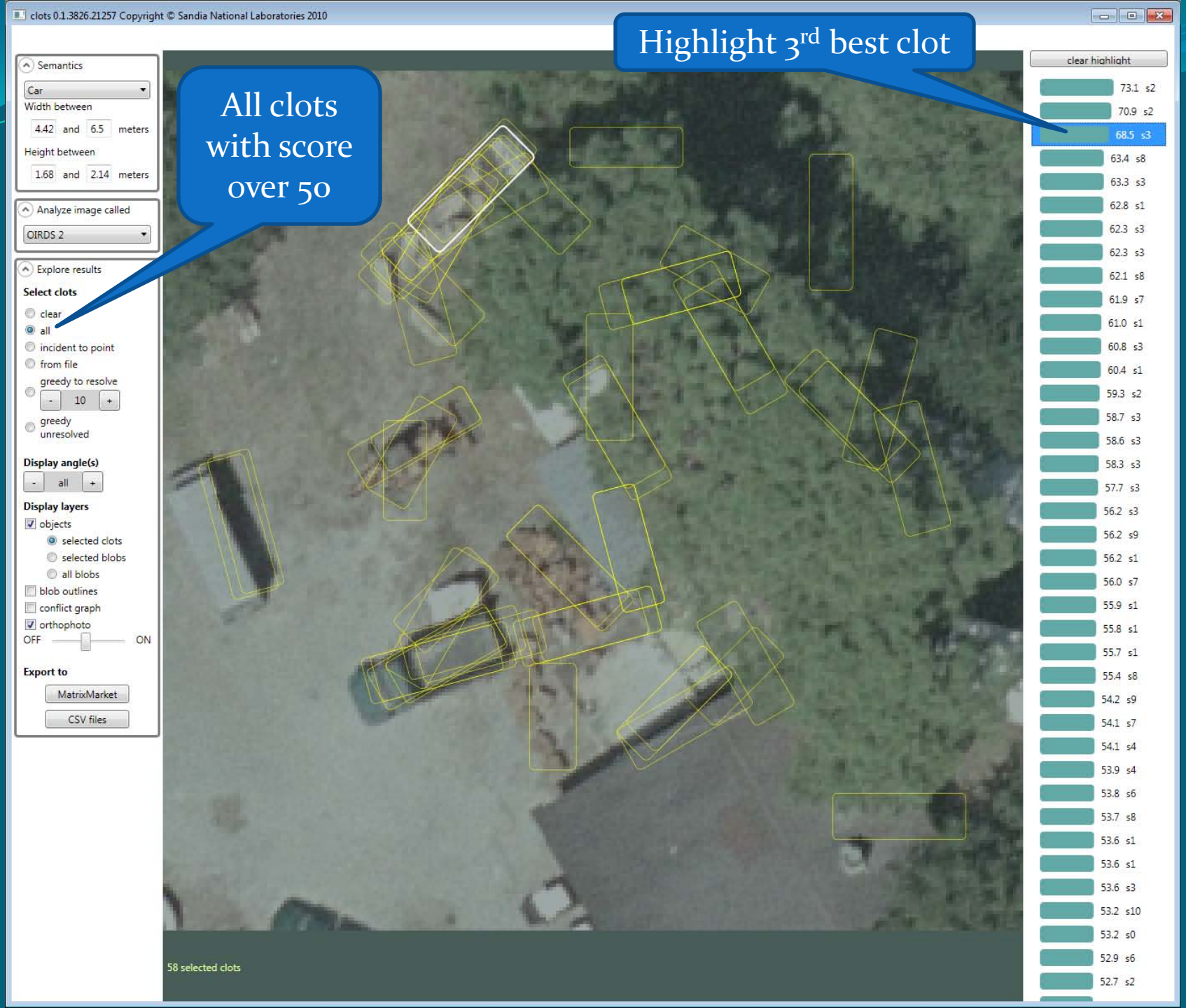

clots 0.1.3826.33568 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 1
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
1
greedy unresolved
Display angle(s)
15
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
clear highlight
66.3 s1
Estimated car shape (clot) is black-dashed rectangle
Car semantics set to constrain car shape to be between these two white-dashed rectangles
Blobs for highlighted clot 2.

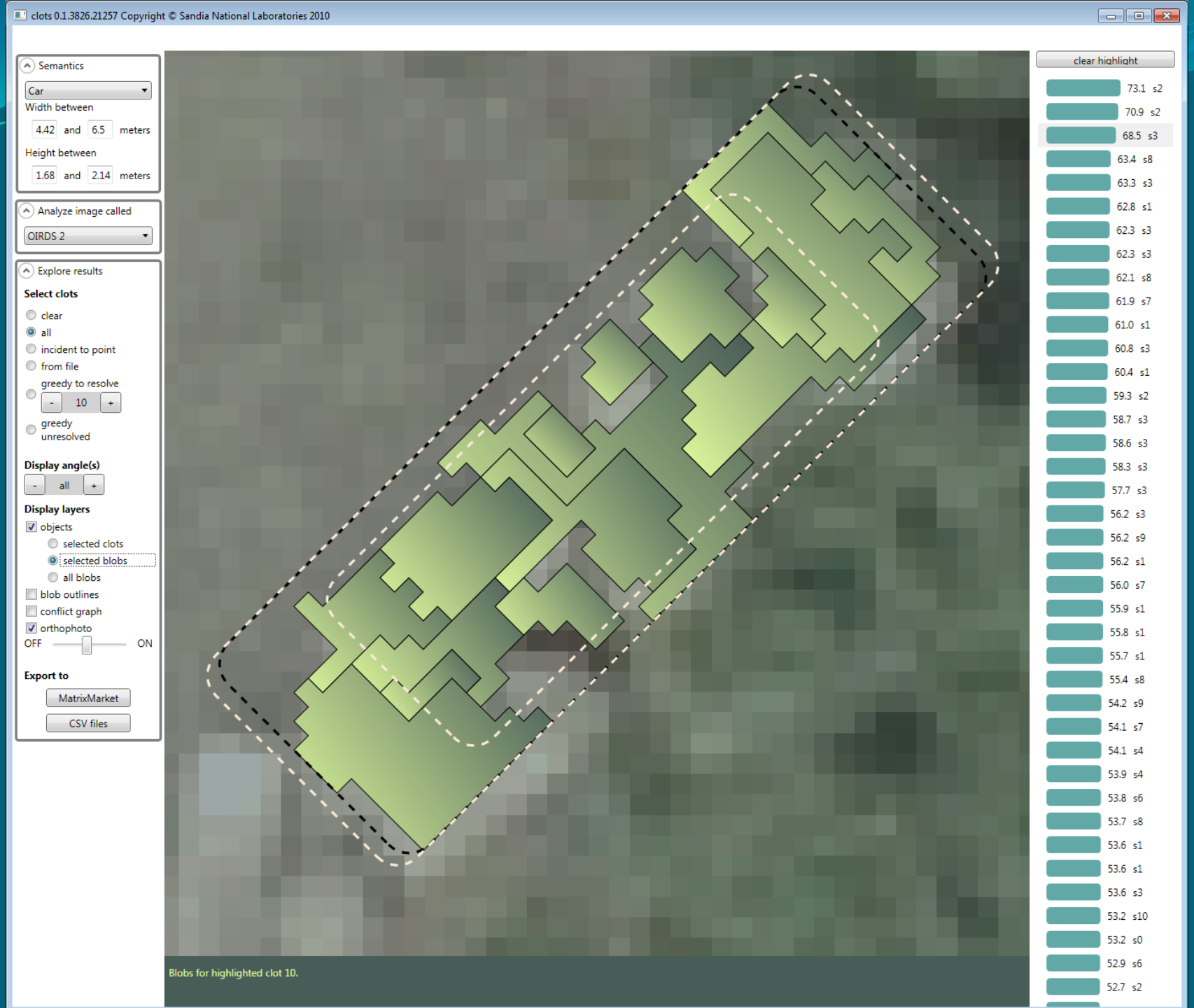
Level of semantic analysis

[collection of image parts] ***is_a*** car	car ***is_a*** [out of place object]
• graph on image parts (blobs) (geospatial mereology?) (obofoundry.org) • car exclusion principle: image part is member of at most one car instance • Diegert's *Combinatorial IOF* talk (this talk)	• graph on image objects (e.g. land cover class instances) • [line of sight] is edge from [car instance] to [door instance] • *Finding Schools* talk at a future brown bag

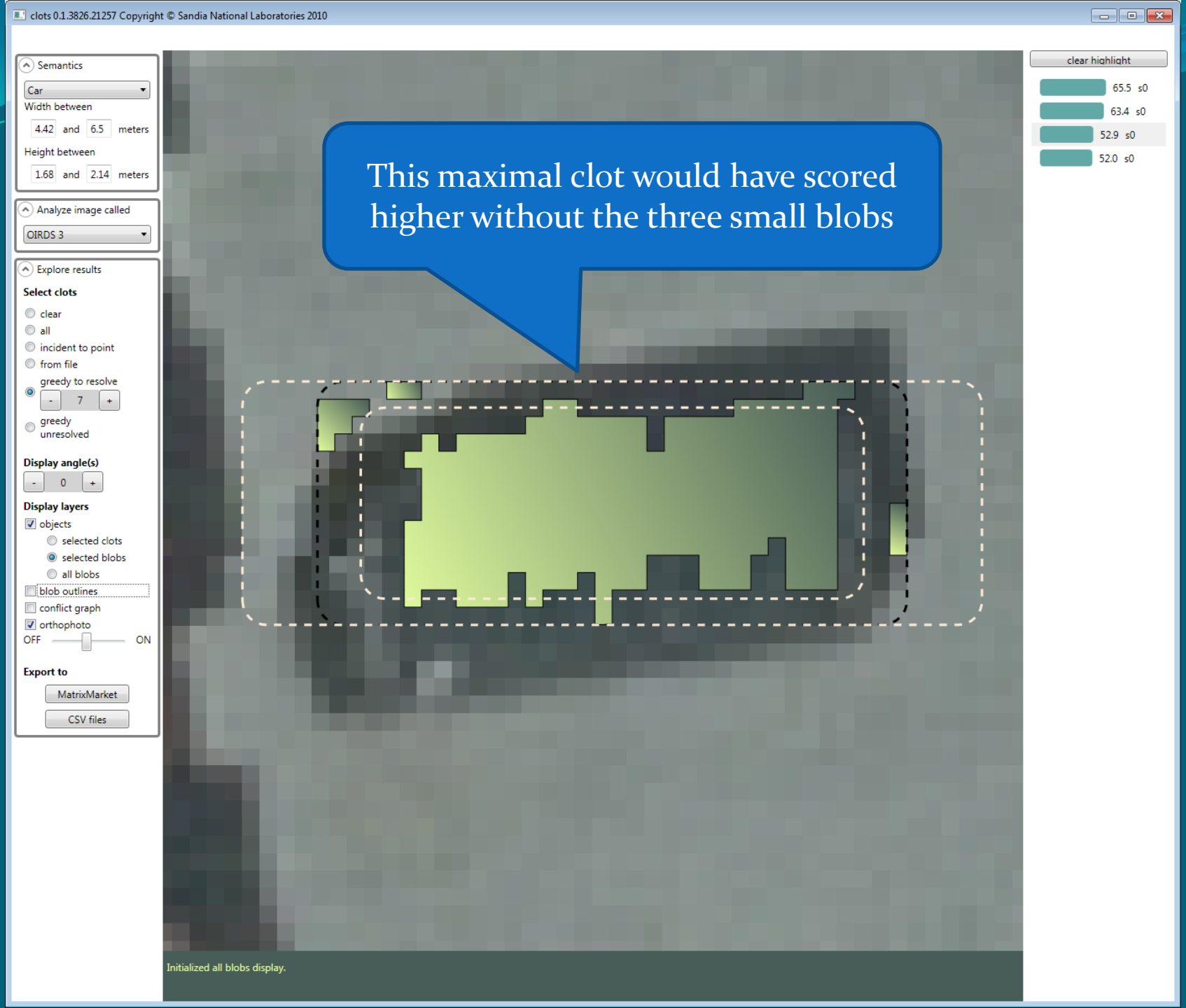

clots 0.1.3826.21257 Copyright © Sandia Nati
Analyze second image from OIRDS
Click to highlight top clot in white
Top 10
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 2
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
10
greedy unresolved
Display angle(s)
all
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
clear highlight
73.1 s2
73.1 s2
68.5 s3
63.4 s8
63.4 s8
62.8 s1
62.8 s1
62.1 s8
61.9 s7
58.6 s3
10 selected clots


clots 0.1.3826.21257 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 2
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
- 10 +
greedy unresolved
Display angle(s)
- all +
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF ON
Export to
MatrixMarket
CSV files
clear highlight
73.1 s2
73.1 s2
68.5 s3
63.4 s8
63.4 s8
62.8 s1
62.8 s1
62.1 s8
61.9 s7
58.6 s3
10 selected clots

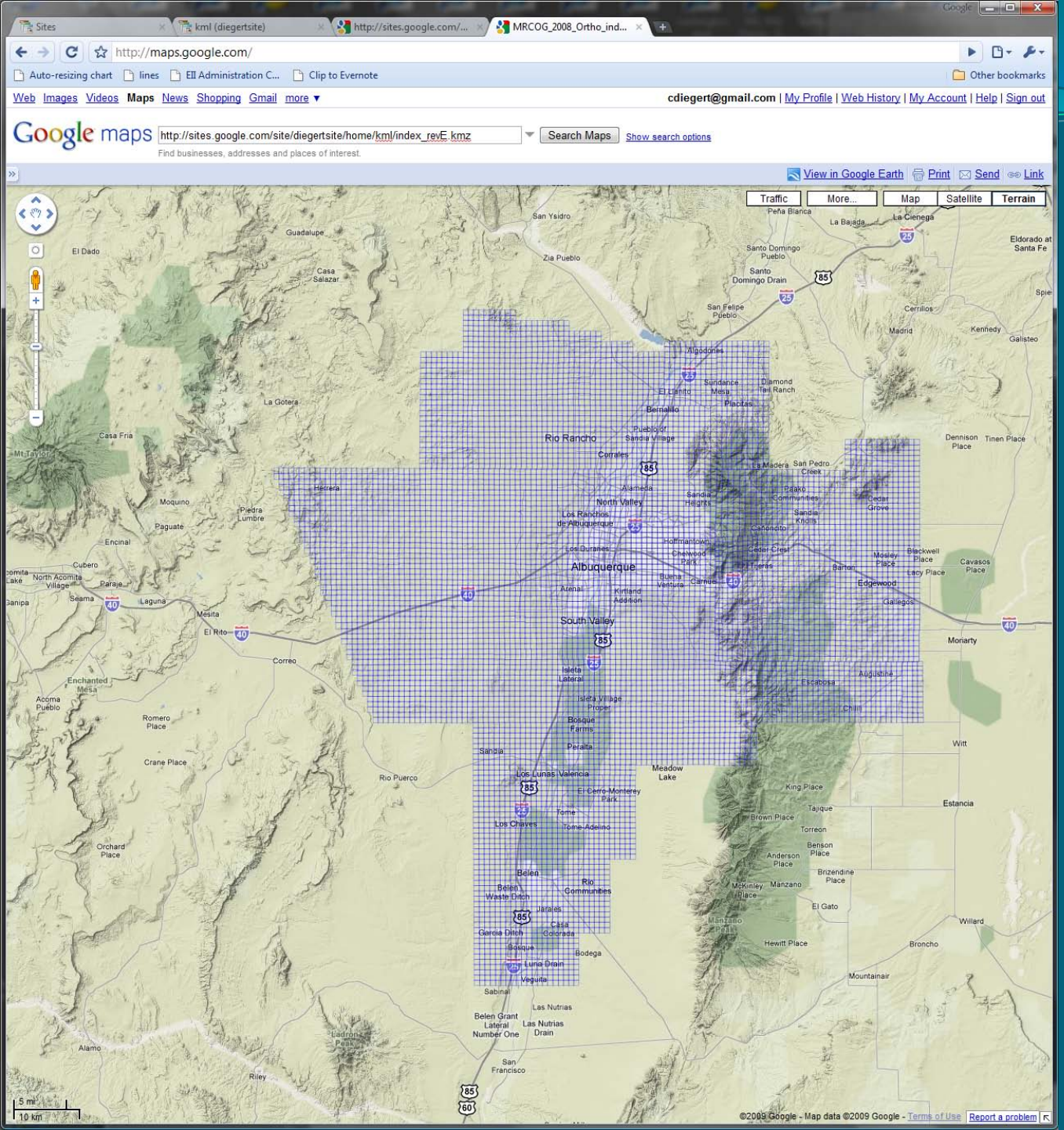

clots 0.1.3826.21257 Copyright © Sandia National Laboratories 2010
Highlight 3rd best clot
All clots with score over 50
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 2
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
10
greedy unresolved
Display angle(s)
all
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
58 selected clots
clear highlight
73.1 s2
70.9 s2
68.5 s3
63.4 s8
63.3 s3
62.8 s1
62.3 s3
62.3 s3
62.1 s8
61.9 s7
61.0 s1
60.8 s3
60.4 s1
59.3 s2
58.7 s3
58.6 s3
58.3 s3
57.7 s3
56.2 s3
56.2 s9
56.2 s1
56.0 s7
55.9 s1
55.8 s1
55.7 s1
55.4 s8
54.2 s9
54.1 s7
54.1 s4
53.9 s4
53.8 s6
53.7 s8
53.6 s1
53.6 s1
53.6 s3
53.2 s10
53.2 s0
52.9 s6
52.7 s2


clots 0.1.3826.21257 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 2
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
- 10 +
greedy unresolved
Display angle(s)
- all +
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
clear highlight
73.1 s2
70.9 s2
68.5 s3
63.4 s8
63.3 s3
62.8 s1
62.3 s3
62.3 s3
62.1 s8
61.9 s7
61.0 s1
60.8 s3
60.4 s1
59.3 s2
58.7 s3
58.6 s3
58.3 s3
57.7 s3
56.2 s3
56.2 s9
56.2 s1
56.0 s7
55.9 s1
55.8 s1
55.7 s1
55.4 s8
54.2 s9
54.1 s7
54.1 s4
53.9 s4
53.8 s6
53.7 s8
53.6 s1
53.6 s1
53.6 s3
53.2 s10
53.2 s0
52.9 s6
52.7 s2
Blobs for highlighted clot 10.

clots 0.1.3826.24474 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
OIRDS 3
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
3
greedy unresolved
Display angle(s)
150
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
clear highlight
63.6 s10
62.7 s10
62.3 s10
54.0 s10
52.4 s10
50.1 s10
Top 3 clots at 150 degrees are on car
3rd OIRDS image
Blobs for highlighted clot 4.
Blobs for highlighted clot 3.
Blobs for highlighted clot 5.



This maximal clot would have scored higher without the three small blobs



2008 Regional Digital Orthophotography Project (1/2 Foot Resolution Data)

In the Spring of 2008 MRCOG acquired over 2200 square miles of natural color, high resolution (1/2 foot GSD) digital orthoimagery in portions of 5 counties (Sandoval, Bernalillo, Santa Fe , Torrance and Valencia). This was a cooperative project with 17 local, State and Federal agencies participating.

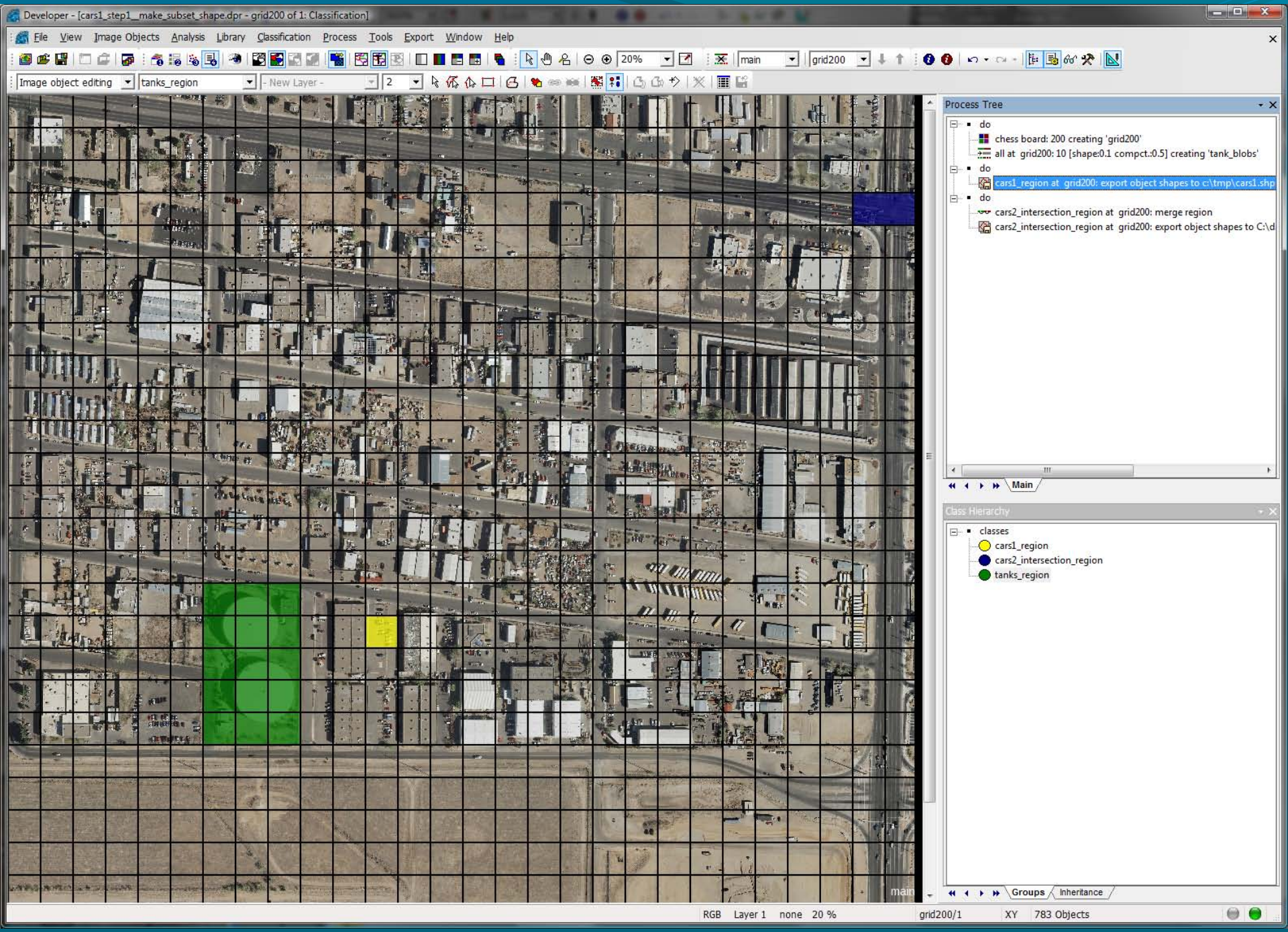
Project cooperators included: City of Albuquerque, Albuquerque Metropolitan Arroyo and Flood Control Authority, Town of Belen, Albuquerque/Bernalillo County Water Utility Authority, Bernalillo County, Town of Edgewood, Isleta Pueblo, Kirtland Air Force Base, Village of Los Lunas, Mid-Region Council of Governments, Middle Rio Grande Conservancy District, City of Rio Rancho, Sandia Pueblo, Sandia National Laboratory, Santa Ana Pueblo, Santa Fe County, and US Geological Survey.

Imagery was acquired in late March and early April 2008. Bohannan Huston, Inc. (BHI) was the contractor for this project.

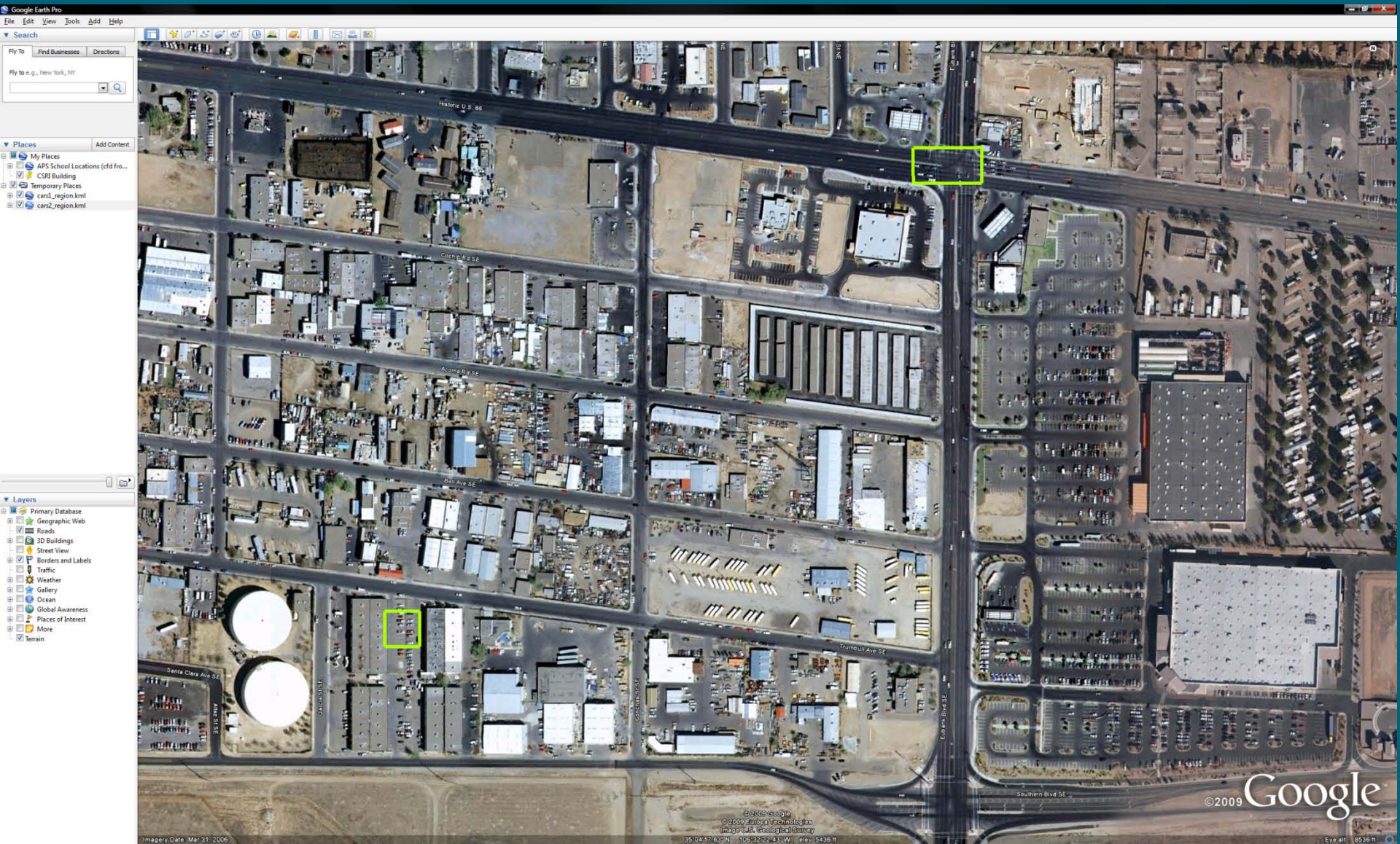
Click here for a map showing coverage extent for the 2008 digital orthoimagery.

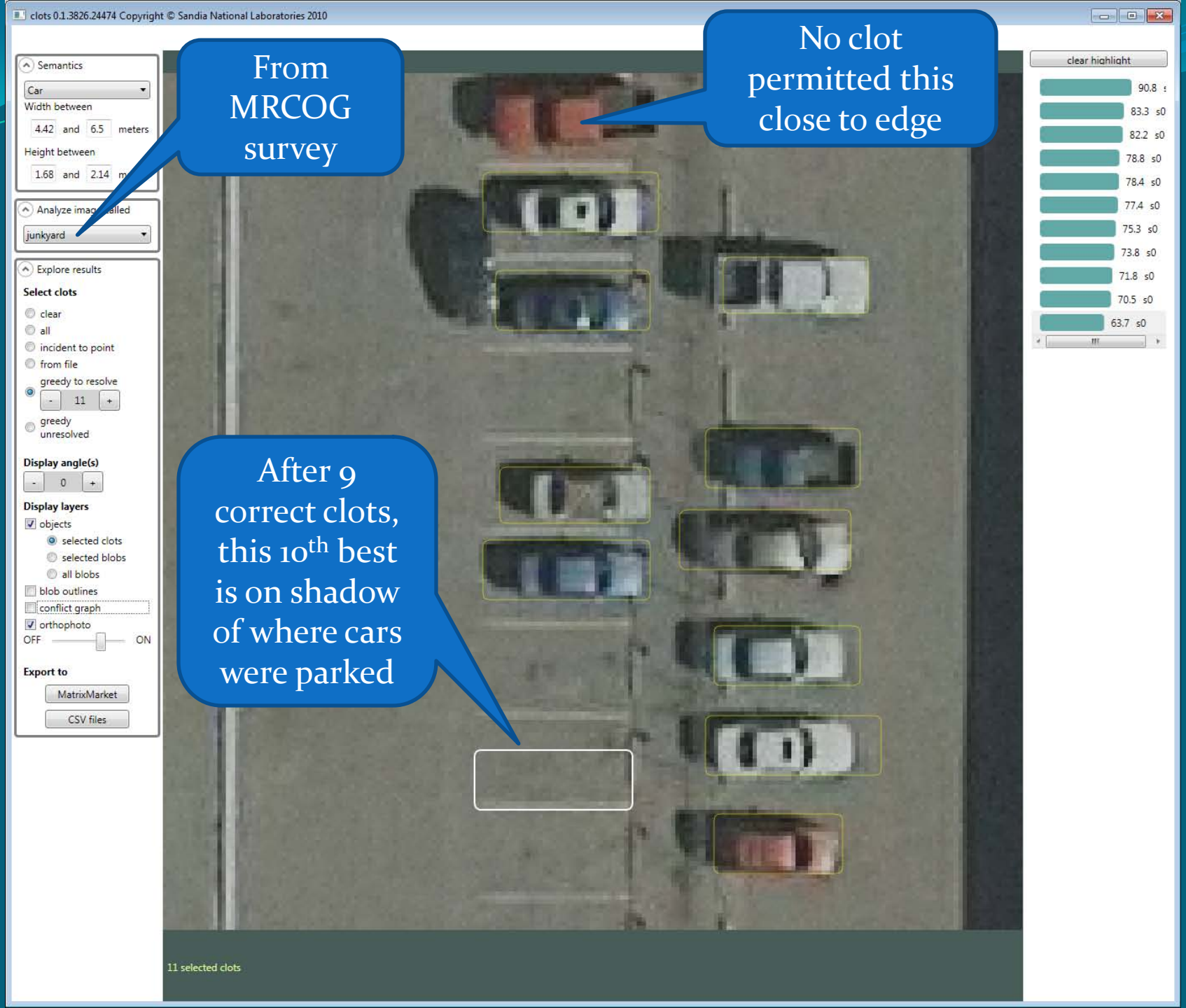
The 2008 imagery in compressed imagery format files (.ecw) should be available soon (summer 2009) for download from RGIS. MRCOG will post the link when available.

http://www.mrcog-nm.gov/content/view/85/200/


Developer - [cars1_step1__make_subset_shape.dpr - grid200 of 1: Classification]
File View Image Objects Analysis Library Classification Process Tools Export Window Help
20%
main
grid200
Image object editing
tanks_region
- New Layer -
2
Process Tree
do
chess board: 200 creating 'grid200'
all at grid200: 10 [shape:0.1 compct.:0.5] creating 'tank_blobs'
do
cars1_region at grid200: export object shapes to c:\tmp\cars1.shp
do
cars2_intersection_region at grid200: merge region
cars2_intersection_region at grid200: export object shapes to C:\d
Main
Class Hierarchy
classes
cars1_region
cars2_intersection_region
tanks_region
Groups
Inheritance
RGB Layer 1 none 20 %
grid200/1
XY
783 Objects

test regions in Google Earth




clots 0.1.3826.24474 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14
junkyard
Explore results
Select clots
clear
all
incident to point
from file
greedy to resolve
11
greedy unresolved
Display angle(s)
0
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
clear highlight
90.8
83.3 s0
82.2 s0
78.8 s0
78.4 s0
77.4 s0
75.3 s0
73.8 s0
71.8 s0
70.5 s0
63.7 s0
11 selected clots
From MRCOG survey
No clot permitted this close to edge
After 9 correct clots, this 10th best is on shadow of where cars were parked

clots 0.1.3826.24474 Copyright © Sandia National Laboratories 2010
Semantics
Car
Width between
4.42 and 6.5 meters
Height between
1.68 and 2.14 meters
Analyze image called
junkyard
Explore results
Select clots
clear
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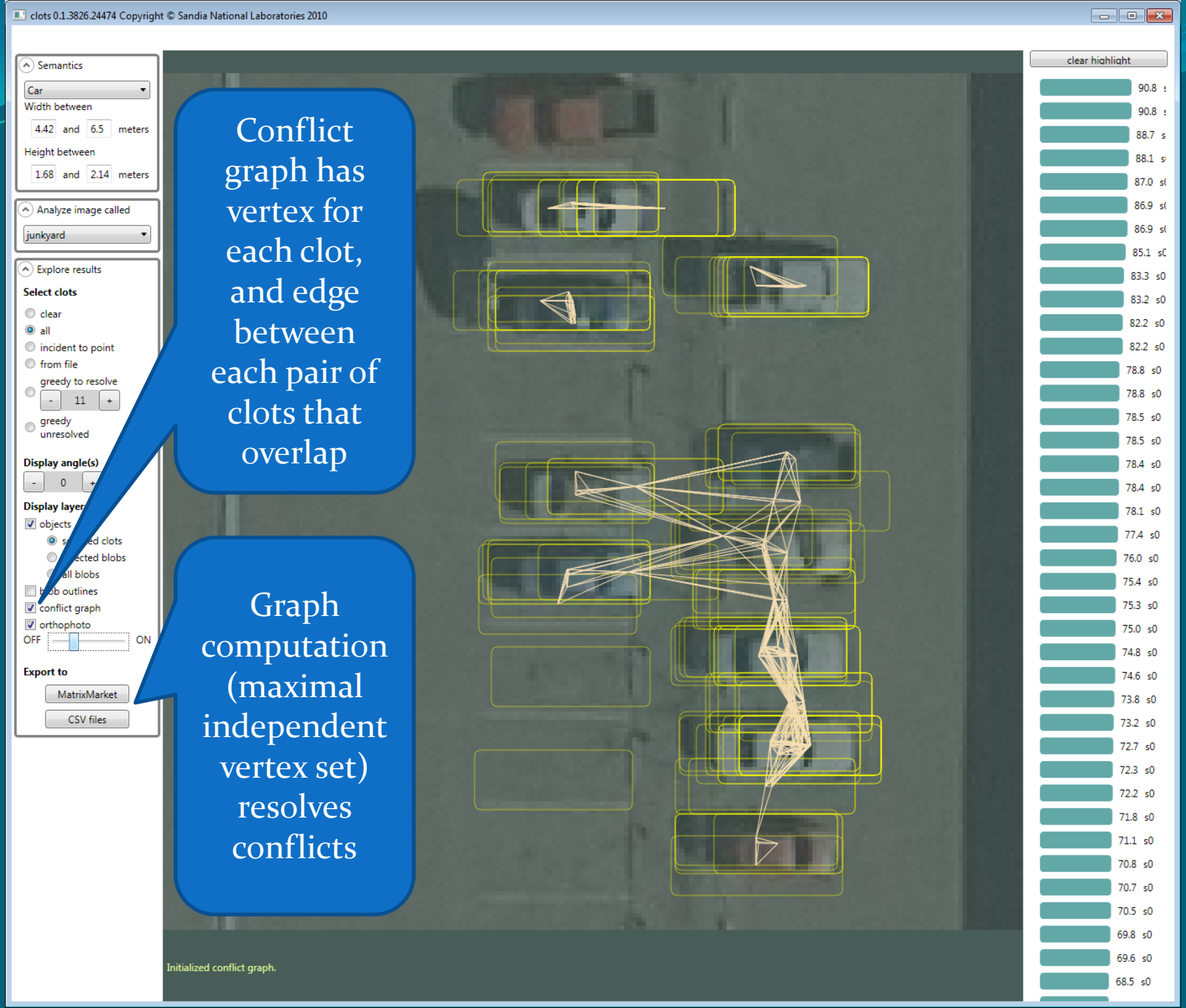
0
Display layers
objects
selected clots
selected blobs
all blobs
blob outlines
conflict graph
orthophoto
OFF
ON
Export to
MatrixMarket
CSV files
clear highlight
99 clots with score over 50, many overlap
99 selected clots

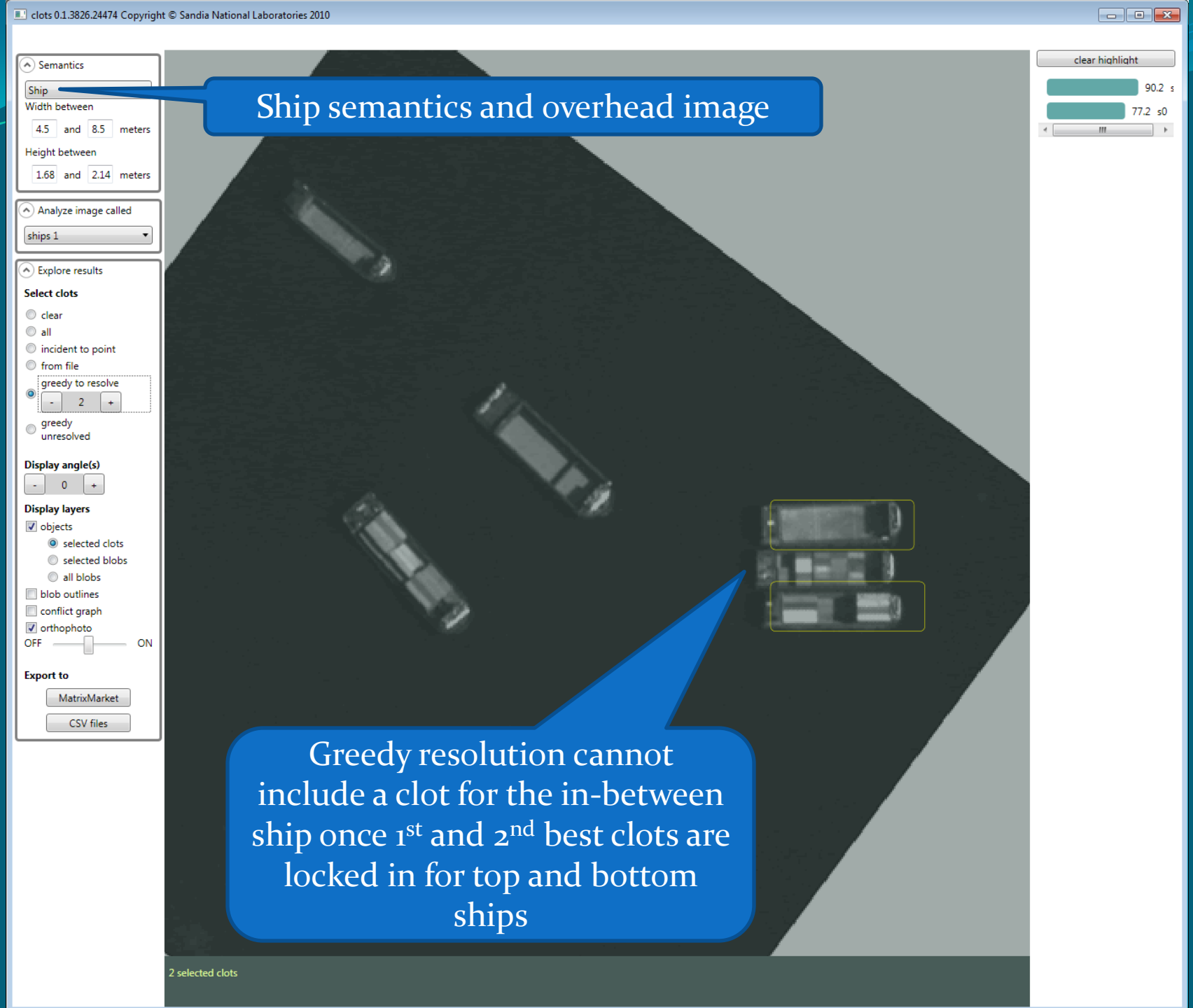


Conflict graph has vertex for each clot, and edge between each pair of clots that overlap

Graph computation (maximal independent vertex set) resolves conflicts

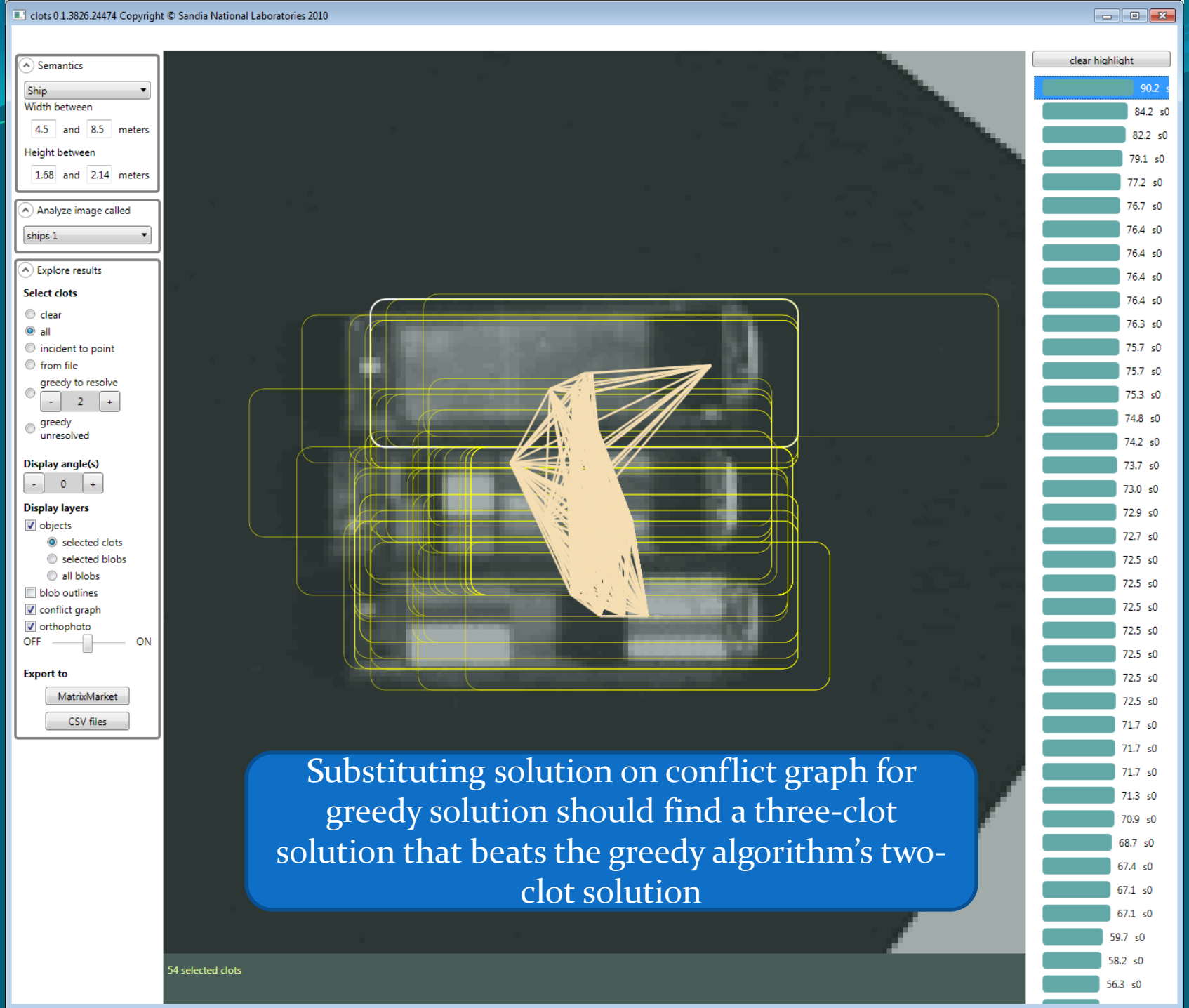
Solutions using conflict graph

Greedy	Maximal independent vertex coloring
• Choose maximal-weight vertex from all vertices not already adjacent to a colored vertex • Color chosen vertex and repeat	• Well-studied graph theory problem • Can only improve on greedy resolution of conflicting car hypotheses



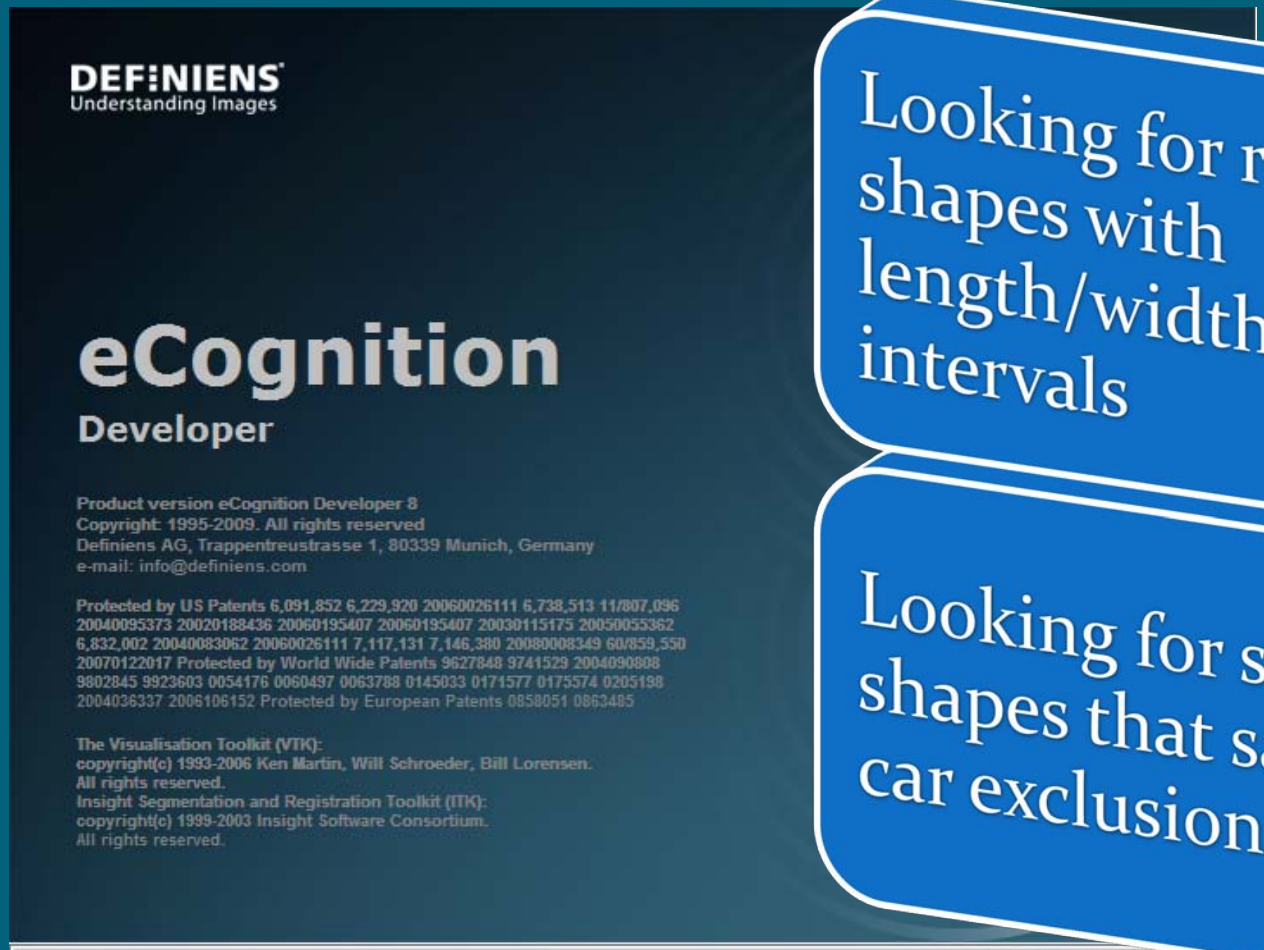
Ship semantics and overhead image

Greedy resolution cannot include a clot for the in-between ship once 1st and 2nd best clots are locked in for top and bottom ships



Substituting solution on conflict graph for greedy solution should find a three-clot solution that beats the greedy algorithm's two-clot solution

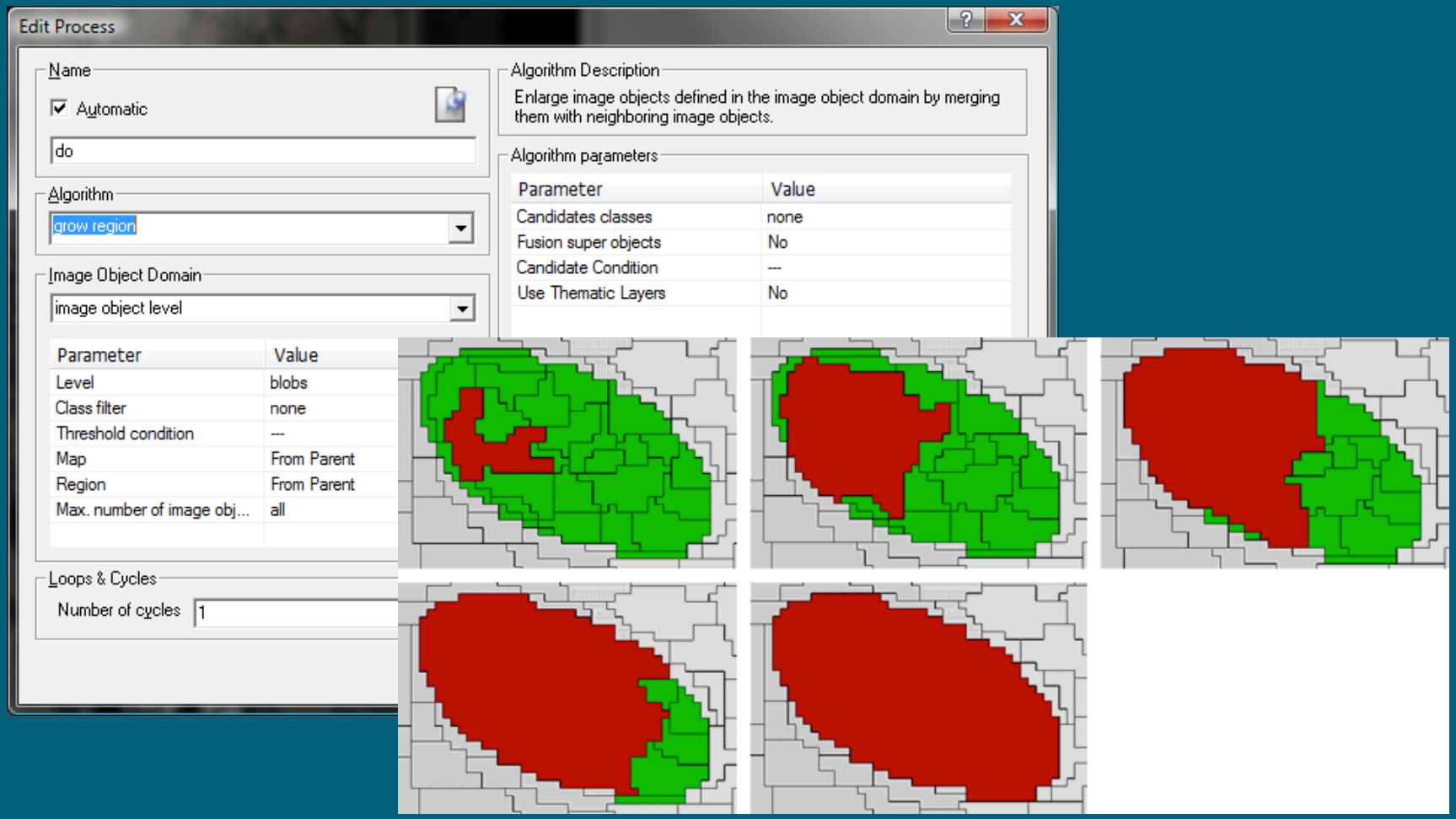
Practical detail:
fit into commercial workflow



Looking for rectangular shapes with length/width in given intervals

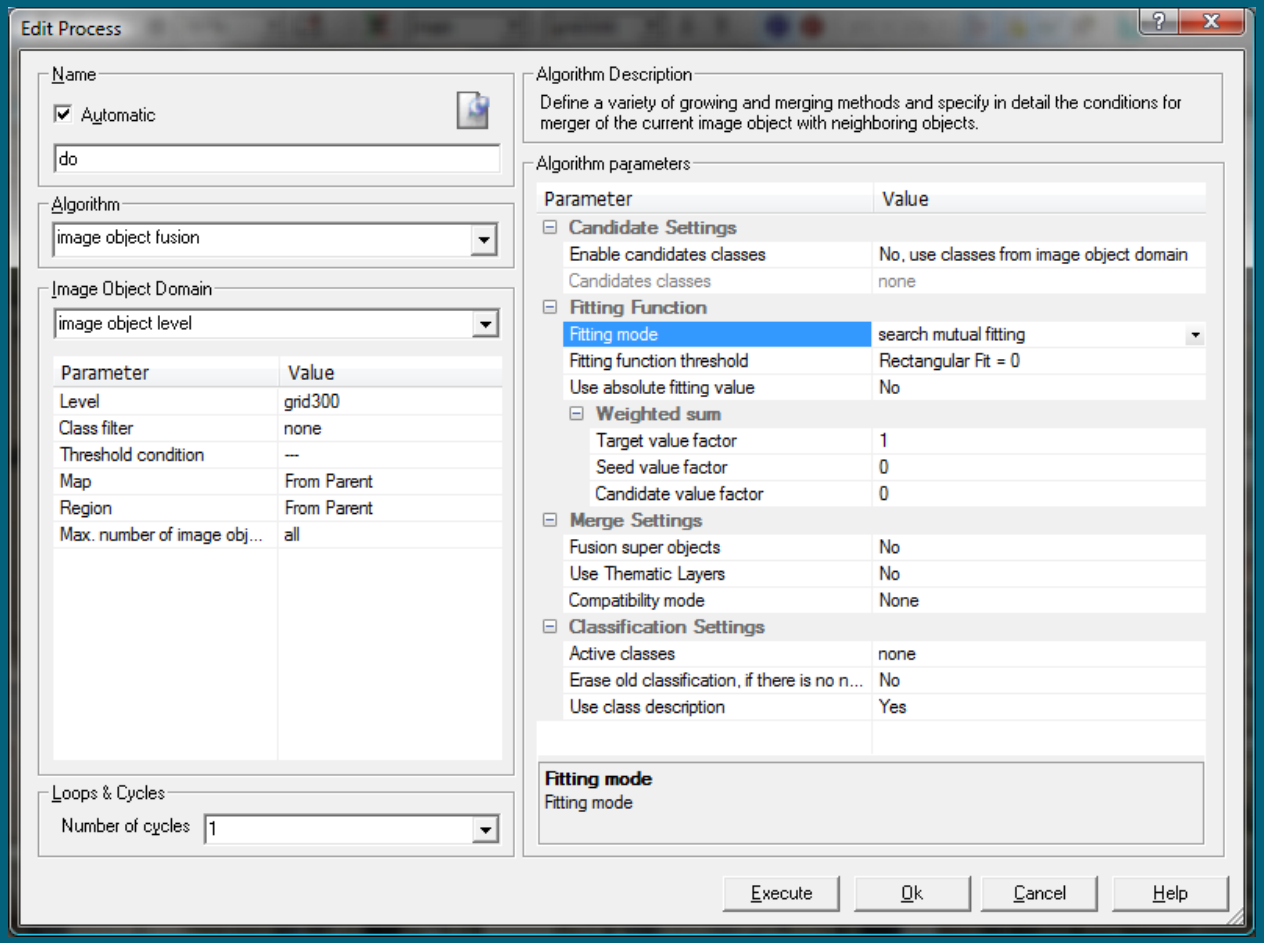
Looking for set of shapes that satisfy the car exclusion principle

Definiens Grow Region



Definiens eCognition Developer 8 User Guide, Document Version 1.2.0, Copyright © 2009, page 58.

Definiens IOF



Beyond Definiens

Definiens eCognition Developer 8 Reference Book, Document Version 1.2.0, Copyright © 2009 Definiens AG, pp 64-65.

Fitting Mode	Description
All fitting	Merges all candidates that match the fitting criteria with the seed.
First fitting	Merges the first candidate that matches the fitting criteria with the seed.
Best fitting	Merges the candidate that matches the fitting criteria in the best way with the seed.
All best fitting	Merges all candidates that match the fitting criteria in the best way with the seed.
Best fitting if mutual	Merges the best candidate if it is calculated as the best for both of the two image objects (seed and candidate) of a combination.
Search mutual fitting	Executes a mutual best fitting search starting from the seed. The two image objects fitting best for both will be merged. Note: These image objects that are finally merged may not be the seed and one of the original candidate but other image objects with an even better fitting.
Search best conflict-free subsets	***High-performance implementation for specific fitting function. No need to seed.***

NEW!

Path forward

Extend shape-based Clots algorithm to also use tone/color of image blobs.

Add tiling and scripting capability to Clots tool to enable analysis of NGA's 900 annotated OIRDS images.

Quantify value of solving maximal independent vertex set problem in place of simple greedy solution.

Invent and implement new methods for buildings, roads, and other man-made shapes.

40 Years of Topology and Geometry for Computation on Segmented Images

Natural concepts of connectedness and simple-connectedness are defined for subsets of a digital picture. It is shown that every simply-connected object (with more than one element) in such a picture has elements which can be deleted without destroying its simpleconnectedness. This makes it easy to prove that a well-known *shrinking* algorithm always works--that is, shrinks any simply-connected object down to a single element. It also becomes easy to show that the natural *edge-following* algorithm, in which one *keeps one's hand on the wall*, follows completely around the edge of any simply-connected object; this result in turn can be used to show that a well-known *border-following* algorithm (in which one follows the border elements of the object rather than the *cracks* between the object and its complement) always works. Various related questions are also treated, among them, that of whether there can exist a *parallel* shrinking algorithm.

Azriel Rosenfeld, 1970.

Rosenfeld, A. 1970. *Connectivity in Digital Pictures*. J. ACM 17, 1 (Jan. 1970), 146-160. DOI= http://doi.acm.org/10.1145/321556.321570.

Geometry and Topology: Region Adjacency Graph and beyond

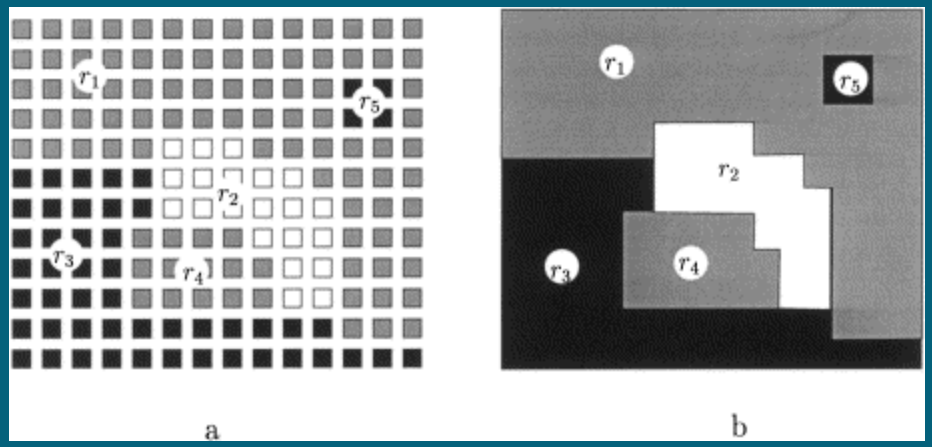


Fig. 1. (a) A discrete image segmented into five regions, respectively labeled r_1–r_5. (b) An embedding of this segmented image into the Euclidean plane.

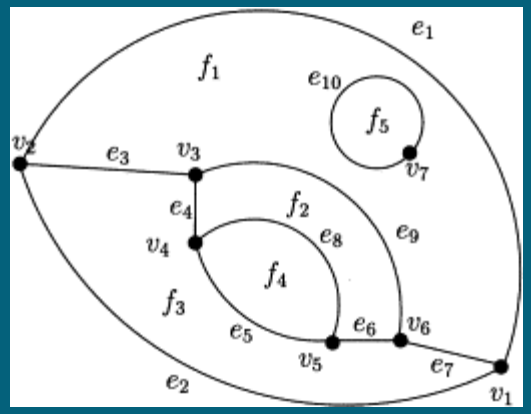


Fig. 2. Two topological maps are associated with the segmented image of Fig. 1. One of them, the single loop, is included in a finite face of the other one. These maps are the boundary maps of the segmented image. Each finite face fi corresponds to one region of the segmented image.

Jean-Pierre Braquelaire, Jean-Philipe Domenger, *Representation of segmented images with discrete geometric maps*, **Image and Vision Computing**, Volume 17, Issue 10, August 1999, Pages 717-718, ISSN 0262-8856, DOI: 10.1016/S0262-8856(98)00152-8. (Whole article is Pages 517-735.)

Clot enumeration algorithm

clots - Microsoft Visual Studio

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Release | Any CPU | SelectedClotsCollection

Segmentation.cs*

clots.Segmentation | compute_clot_stats(Clot c)

```
        public List<int> iclotSelected = null;

        public Segmentation()...
        /// <summary> ...
        static double blobArea(PointCollection pc)...
        void computeBlobAreas()...
        void computeBlobBoundingBoxes()...
        void computeClotStuff()...
        public void selectClots(Point p)...
        public void loadAndProcess(String fileNameArg, CarSemantics cs)...
        private void fillBlobsFromShapefile()...
        private void computeBlobHulls()...
        public void enumerateClots()
        {
            Enumeration algorithm overview
            Step 1: Build index (small_blobs) into blobs that fit inside a (hmax,wmax) box.
            Step 2: Consider each blob in small_blobs as x-anchor blob
        } // enumerateClots() method
        private void compute_clot_stats(Clot c)...
        private void fill_out(Clot c)...
        public void populate_edges()...
        public void export_to_MatrixMarket()...
        private String my_version()...
        public void export_to_csv()...
    } // class segmentation
    public class ReverseComparer : IComparer<double>...
} // namespace
```

Ready | Ln 557 | Col 37 | Ch 37 | INS

Enumerate clots overview

clots - Microsoft Visual Studio

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Segmentation.cs*

clots.Segmentation | compute_clot_stats(Clot c)

```
        public void selectClots(Point p)...
        public void loadAndProcess(String fileNameArg, CarSemantics cs)...
        private void fillBlobsFromShapefile()...
        private void computeBlobHulls()...
        public void enumerateClots()
        {
            #region Enumeration algorithm overview
            // Each clot has an x-anchor blob and a y-anchor blob,
            // not necessarily distinct.
            // Enumerate each blob (actually, each blob in small_blobs)
            // as possible x-anchor blob.
            // Enumberate in order of ascending x-coordinate value
            // and skip multiple blobs b with same xmin(b) value.
            // Given a candidate x-anchor blob,
            // enumerate all possible y-anchor blobs.
            // Generate maximal clot for each distinct (x,y) point with
            // a valid corresponding pair of blobs for x-anchor and y-anchor.

            // Enumerating clots depends on current values from car semantics.
            // CarSemantics cs = (CarSemantics)this.
            #endregion
            Step 1: Build index (small_blobs) into blobs that fit inside a (hmax,wmax) box.
            Step 2: Consider each blob in small_blobs as x-anchor blob
        } // enumerateClots() method
        private void compute_clot_stats(Clot c)...
        private void fill_out(Clot c)...
        public void populate_edges()...
        public void export_to_MatrixMarket()...
        private String my_version()...
```

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Release | Any CPU | SelectedClotsCollection

Segmentation.cs*

clots.Segmentation | enumerateClots()

```
public void enumerateClots()
{
    Enumeration algorithm overview
    Step 1: Build index (small_blobs) into blobs that fit inside a (hmax,wmax) box.
    #region Step 2: Consider each blob in small_blobs as x-anchor blob
    {
        precompute for quick retrieval of blobs by bounding-box attribute

        // Consider each of blob in  this.small_blobs  as x-anchor blob.
        // However, consider them in order of increasing x-coordinate value.
        for (int xrank = 0; xrank < cc; xrank++)
        {
            int iblob_xanchor = iminx[xrank];
            Blob xa = this.blobs[iblob_xanchor];
            Rect rxa = xa.boundingBox;
            TRACE: Enumerating for x-anchor blob  xa
            PROOF: ymin(ya) is in [ ymax(xa)-hmax, ymin(xa) ]
            // Given  xa  enumerate all possible y-anchor blobs.

            // Note: in Microsoft WPF "top" is MINIMUM, since they have origin at UPPER-left
            // Our origin is LOWER-left

            double tymin = xa.boundingBox.Bottom - hmax;
            double tymax = xa.boundingBox.Top;
            int isymin = Array.BinarySearch(symin, tymin);
            if (isymin < 0) isymin = ~isymin;

            Loop over b with ymin(b) in [tymin,tymax]. Form and save unique clots to this.clots.
        } // xanchor blobs
    } // working with sorted blob arrays
    #endregion
} // enumerateClots() method
```

Ready | Ln 452 | Col 4 | Ch 4 | INS

Backup slides

Blogger: User Profile: Jarl...

http://www.blogger.com/profile/08554942198390184997

Blogger™ Push-Button Publishing

Photo

View Full Size

Contact

- My Web Page

User Stats

On Blogger Since	November 2007
Profile Views (approximate)	570

Jarlath O'Neil-Dunne

- Gender: Male
- Industry: Education
- Occupation: Geospatial Analyst
- Location: Burlington : Vermont : United States

About Me

I am a geospatial analyst with the University of Vermont's (UVM) Spatial Analysis Laboratory. I first became fascinated with geospatial technology after hearing a lecture on Landsat when I was an undergraduate at the University of New Hampshire. My research these days ranges from examining issues of environmental justice to developing procedures to automate the extraction of land cover information from high resolution remotely sensed data. For over a decade I served (active and reserve) with infantry and geospatial intelligence units in the United States Marine Corps.

My Blogs

Letters from the SAL

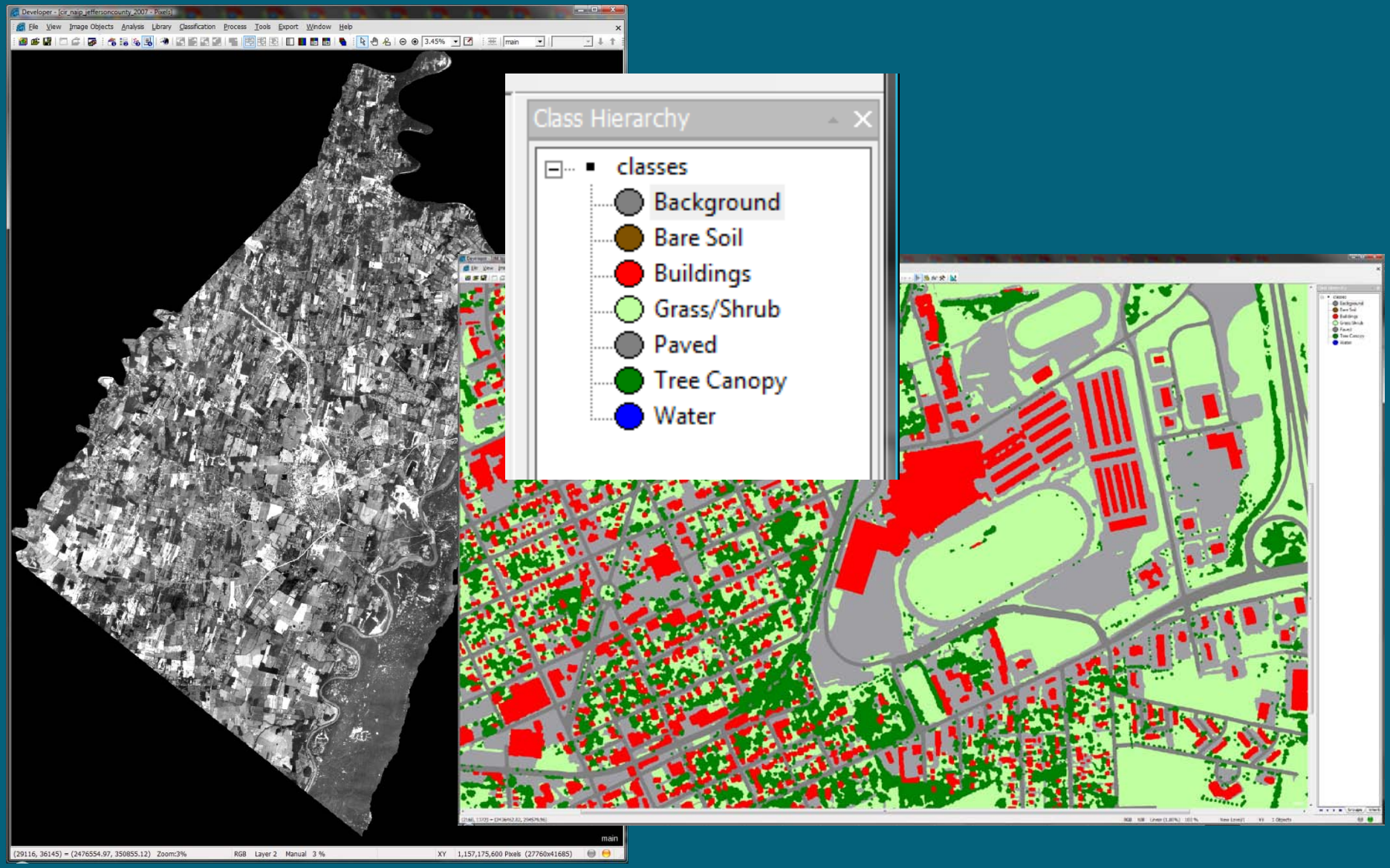
AmericaView Blog

Team Members

dayne The Navigator Tyler Erickson P.R. Blackwell

Blogs I Follow

Greetings from Manasquan, NJ

Urban Tree Canopy (UTC) news from Casey Trees

Jaralath + OBIA Workflow = landcover classification