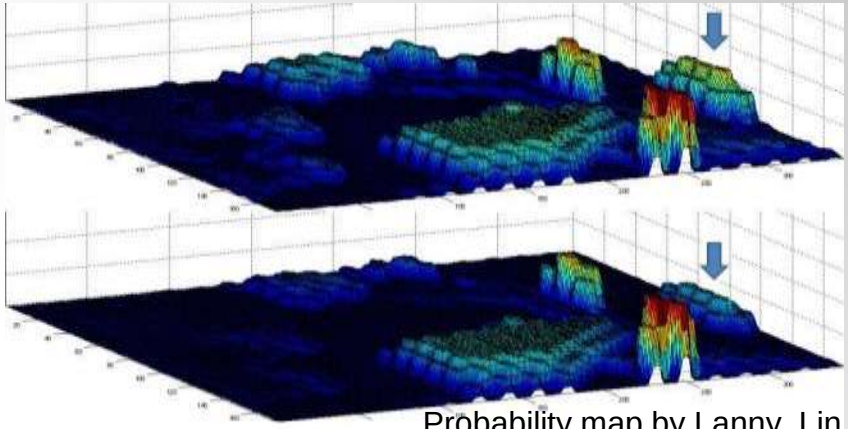
MapScore:
Probability Map Evaluation for Search & Rescue



Probability map by Lanny Lin

Eric Cawi, Nathan Jones, Dr. Charles Twardy

Funded by an NSF “Research Experience for Undergraduates” grant to colleagues at Brigham Young University. Many thanks to NSF and BYU

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Agenda

- Introduction / Context
- Website Walkthrough
- ESRI models using Koester's stats
- Tabletop Exercise

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NSF REU with BYU

The BYU team (above) & UAV bait (below)

- **BYU** had a different approach to making probability maps.
- How can we compare?
- BYU offered us REU funding on their WiSAR project for MapScore.
- We hired two *great* students
  - Nathan Jones (website)
  - Eric Cawi (GIS models)

Many thanks to the WiSAR team at BYU and to the NSF!

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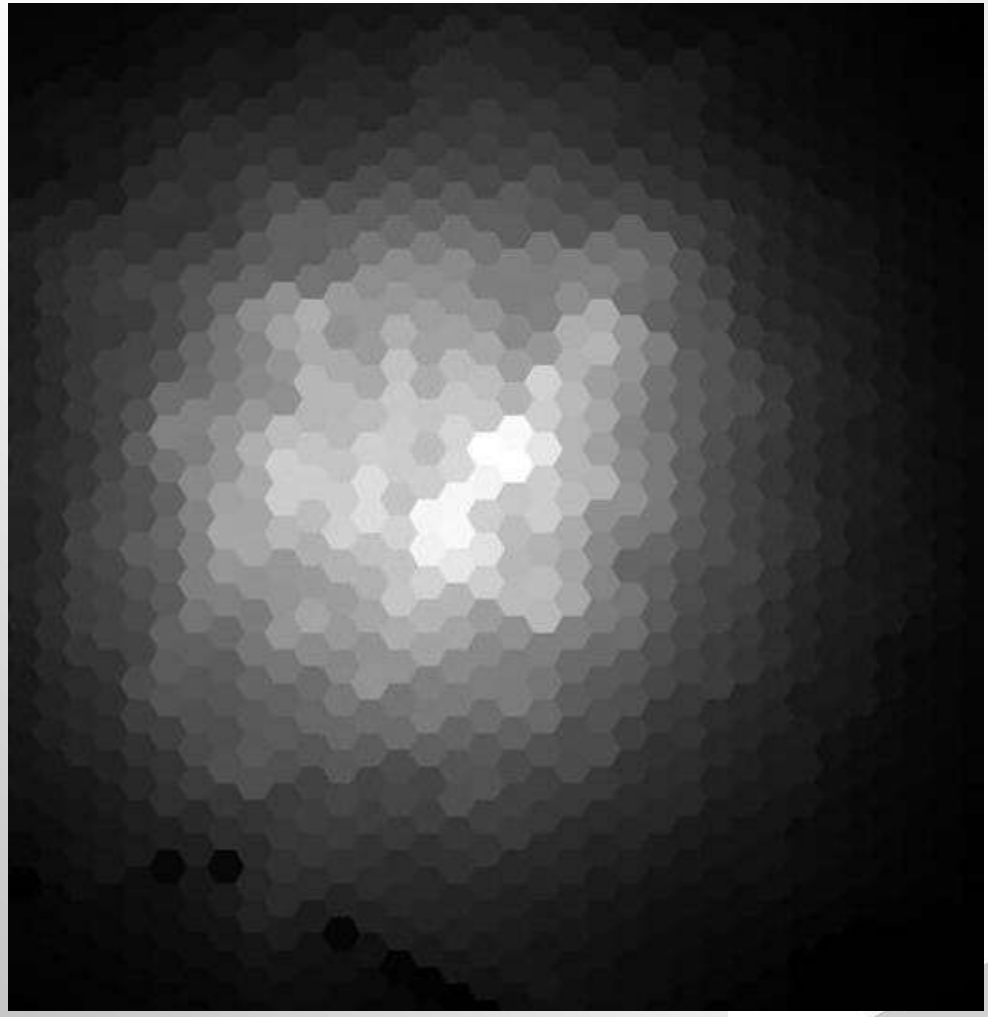
BYU Motion Model



New York 53 (46yo male camper)

Probability Map by Lanny Lin
Brigham Young University

Score: 0.98558 (**98+%**)

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MapScore Functional Goals

- Provide researchers with an environment to test probability maps based on actual lost person scenarios.

- Establish competition among research groups to create the most accurate models.

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mapscore.sarbayes.org

Main Menu

George Mason University:
Lost Person Model Rating System

Main Menu

Welcome to the lost person model rating system. This system is intended to provide academic and research affiliated organizations with an opportunity to compare their lost person models with other models being developed in the field.

Top Rated Models

Institution Name	Model Name	Average Rating	Tests Completed
Virginia Tech	Hokie	0.99758	1
TestA	Alpha	0.99758	1
University of Virginia	Cavalier	0.0	1
William and Mary	Arrow	-0.24642	1
Columbia University	Manhattan	-0.98046	1

Accept New Test Case

George Mason University:
Lost Person Model Rating System

[Log Out | Leaderboard] *Test Selection* [Issue Tracker | Help]

Initial Planning Point (IPP)

Account Name: TestA
Model Name: Alpha

A new testing scenario has been randomly chosen for you to complete. Once completed this scenario will be rated by our system and your model's standings will be updated. Once this scenario is accepted, you will go through a set of standard procedures to complete the test.

Provided below are the known lost person scenario parameters:

Test Case Name: *Hiker01*

Required Coordinate System: *WGS_84*

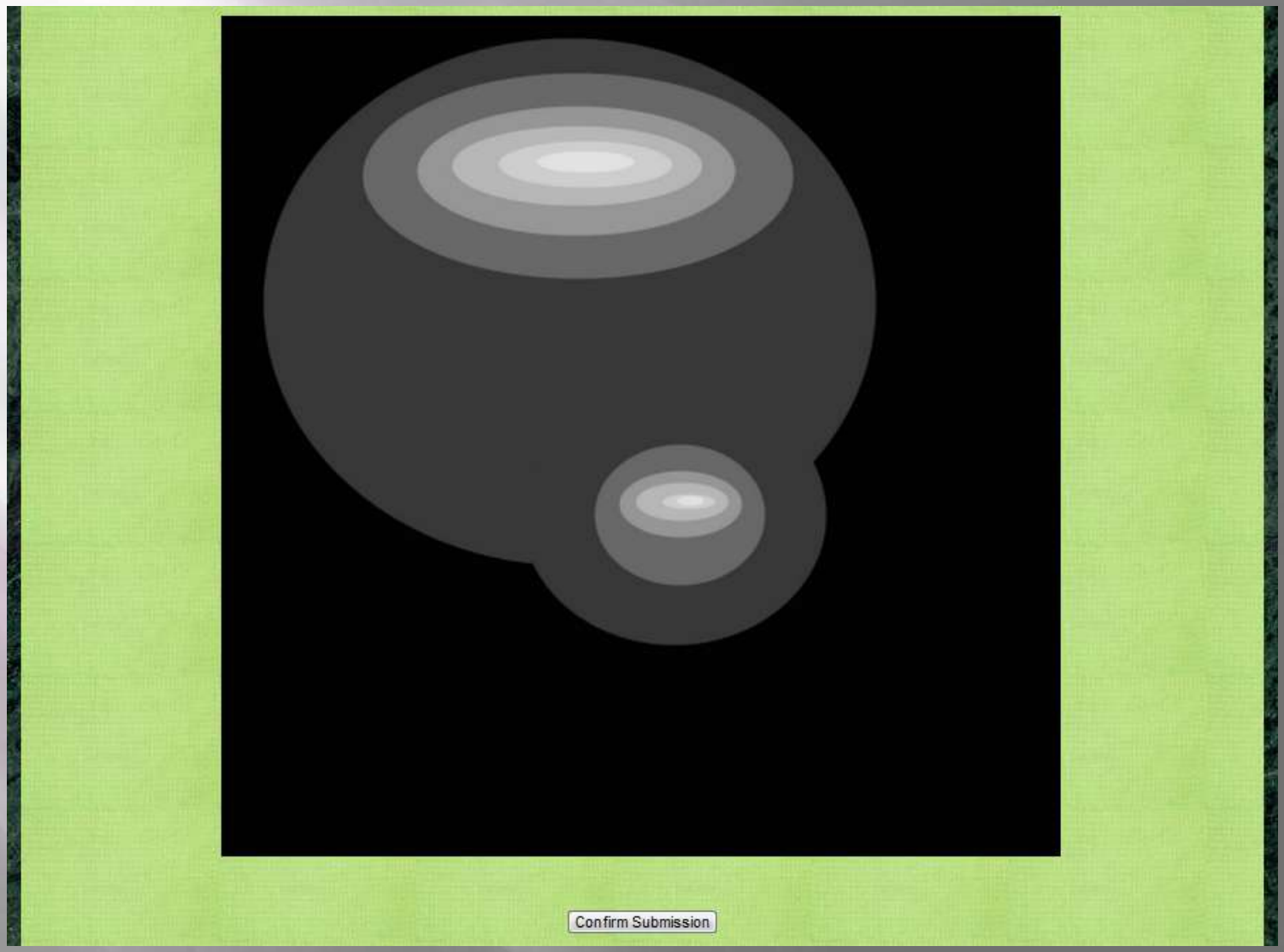
Subject(s) Information:

Subject age: *34*
Subject sex: *F*
Subject Category: *Hiker*
Scenario: *Medical*
Subject Sub-Category: *UNDOCUMENTED ALIEN*
Subject Activity: *Hiking*
Group Type: *F*
Number Lost: *1*

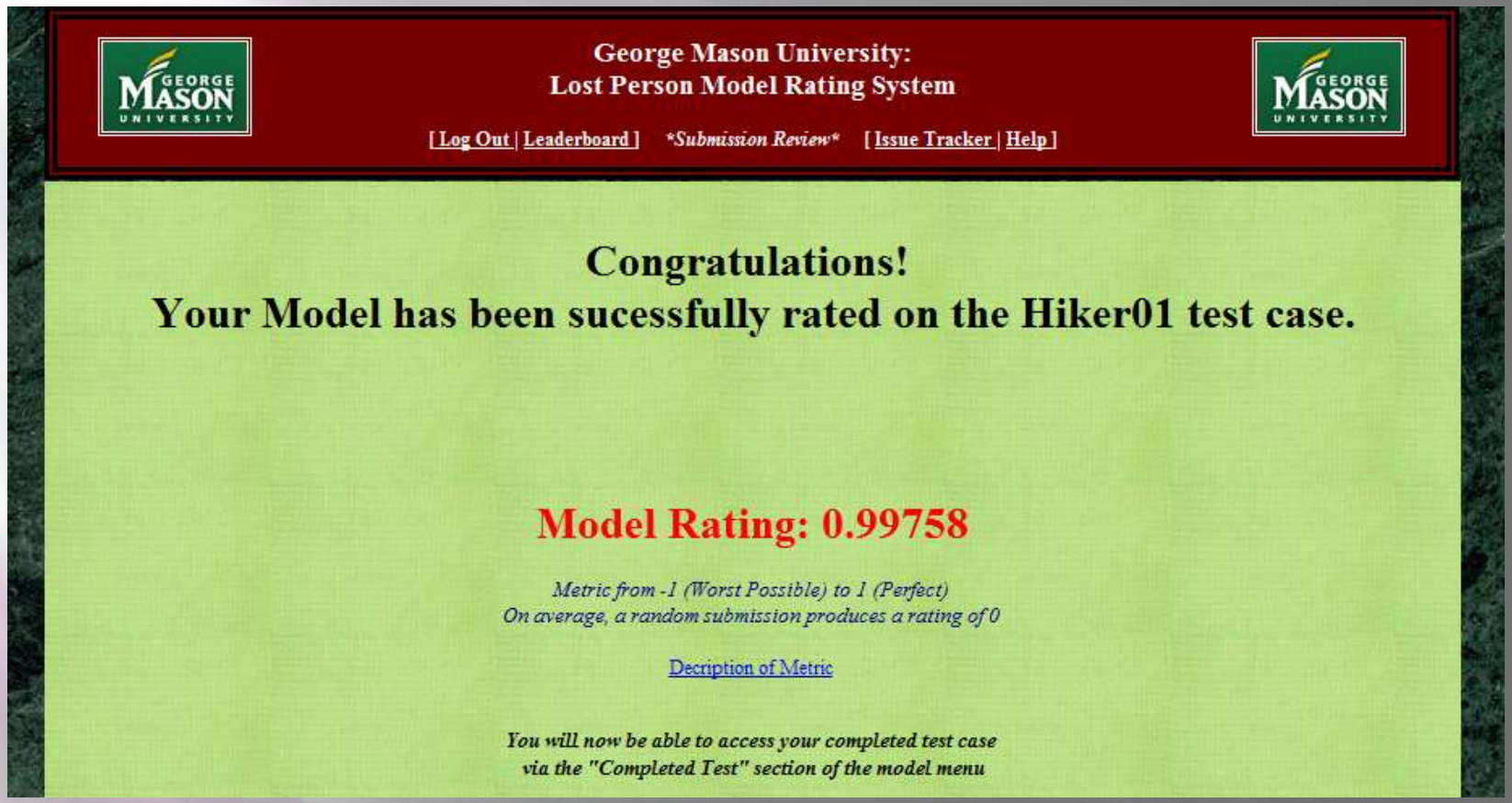
Search Region Information:

Terrain: *Mountainous*
Ecoregion Domain: *Dry*

Probability Map Upload



Probability Map Rating



Rossmo Metric

- ***P* = prob(the find location)**
- ***r* = proportion of pixels > *P***
  - Roughly.
  - Add half the pixels with prob = *P*. (Koester)
- **Scaled to be more intuitive**
  - ***R* = (.5 – *r*)/(.5)**
  - **Range = - 1 (bad) to 1 (good)**

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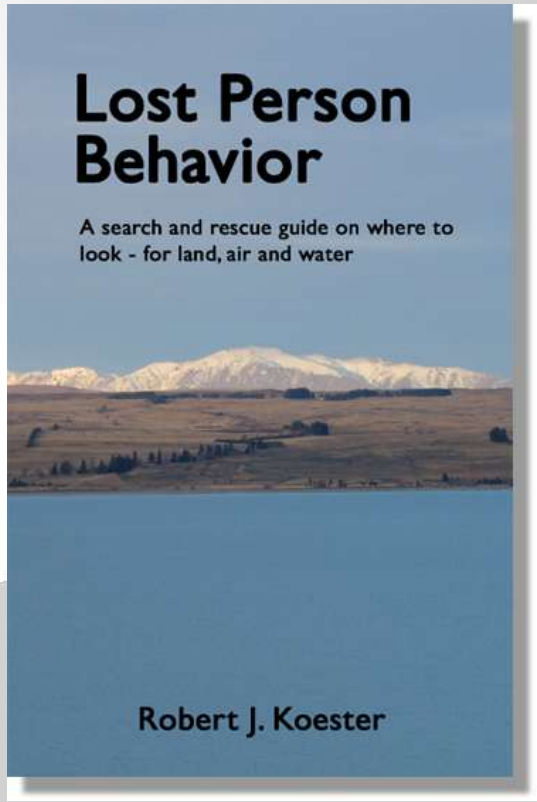
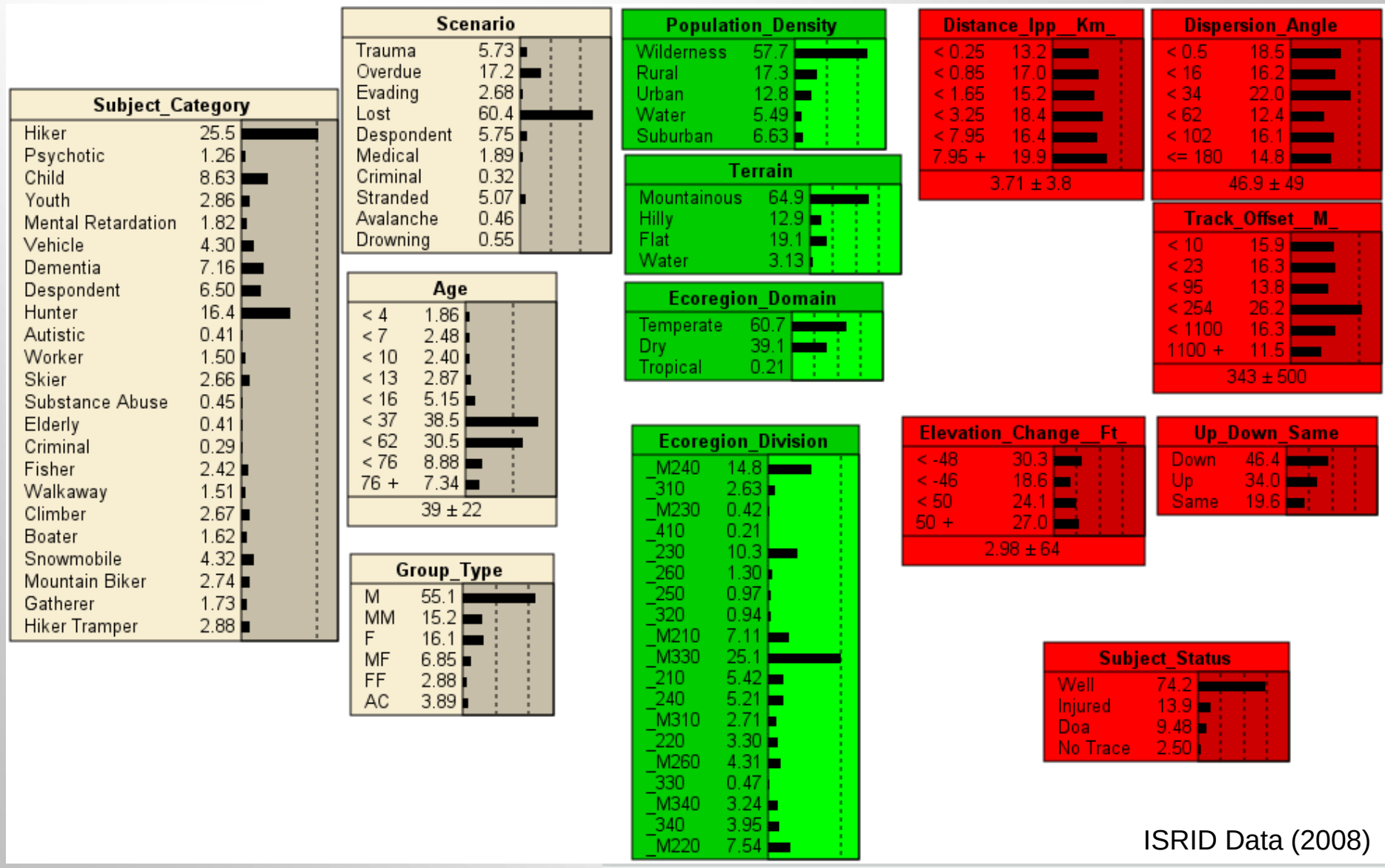
Modified E**SRI** Models

- Distance from IPP
- Elevation Change from IPP
- Linear Features/Track offset
- Find Location

Base models created for Yosemite by Liz Sarow, ESRI.
Based on statistics from
***Lost Person Behavior* by Robert Koester.**
Generalized & modified for MapScore by Eric Cawi.



Lost Person Behavior: Many Vars



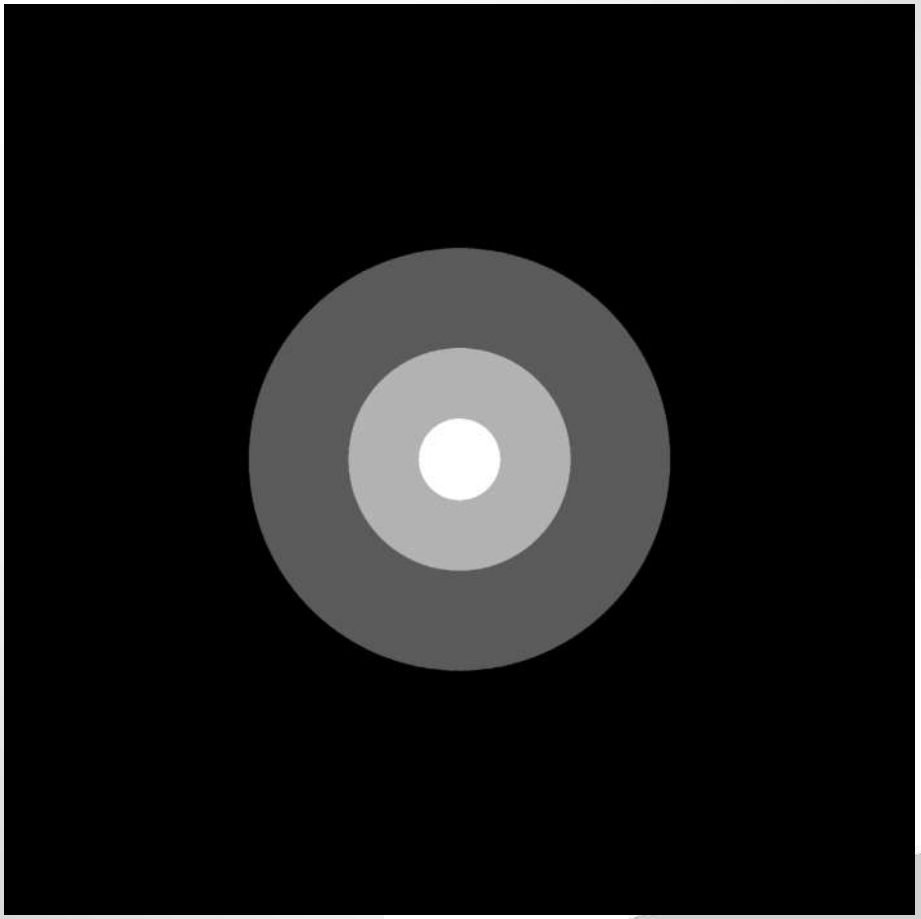
ISRID Data (2008)

Example Distance Map for Scoring

I've adjusted the brightness and contrast of all the greyscale maps so they look better on my monitor. ☺

The actual values given to the computer are sometimes hard for the eye to distinguish.

But the scoring metric cares only about relative value anyway.



From the New York 108 Case

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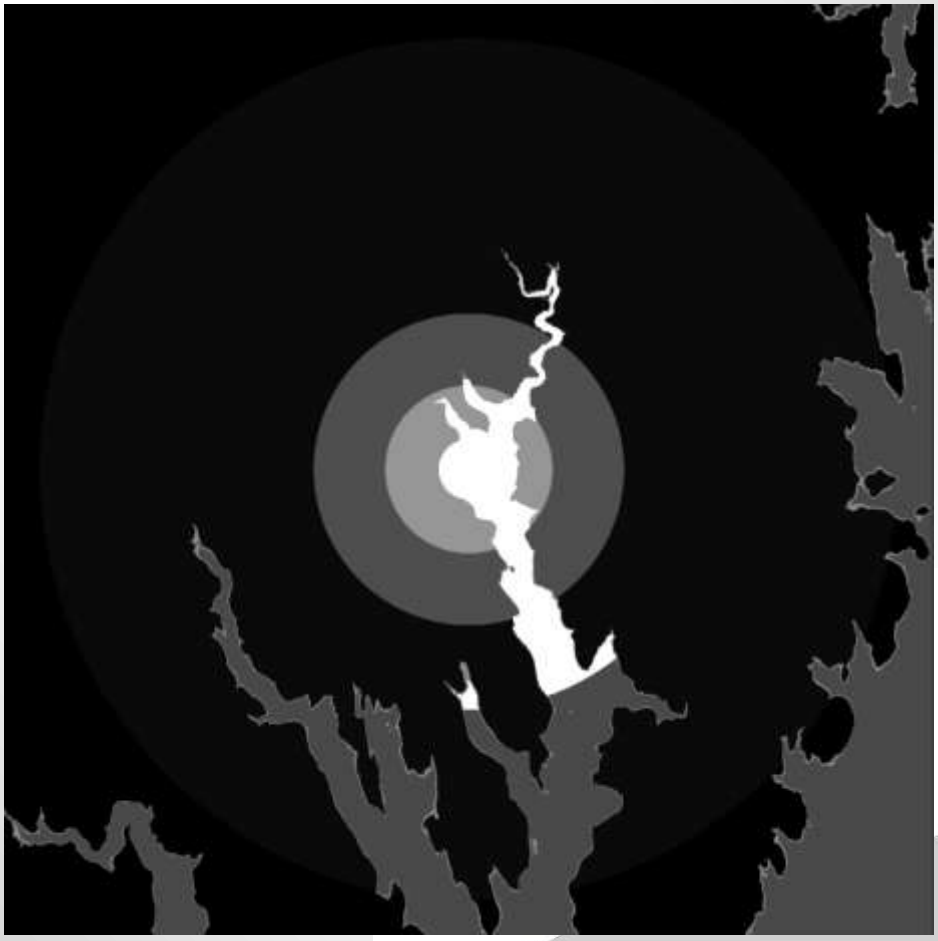
Example Elevation Probability Map (Hiker Model)



From the New York 108 Case

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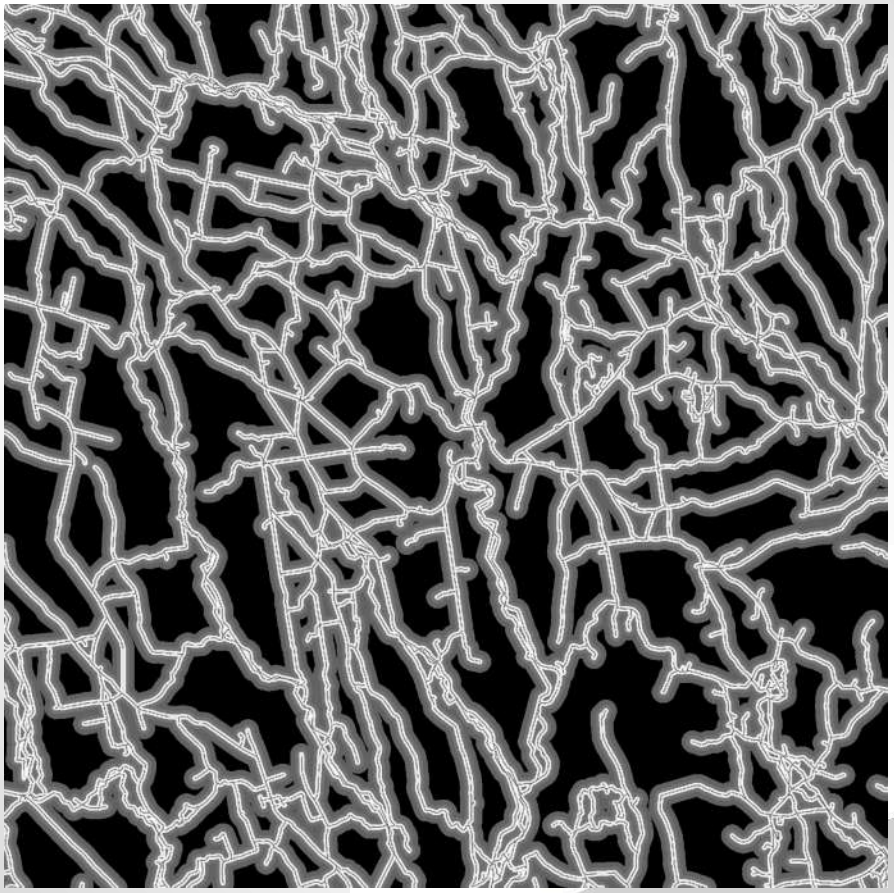
Example Linear Features Probability Map



From the New York 108 Case

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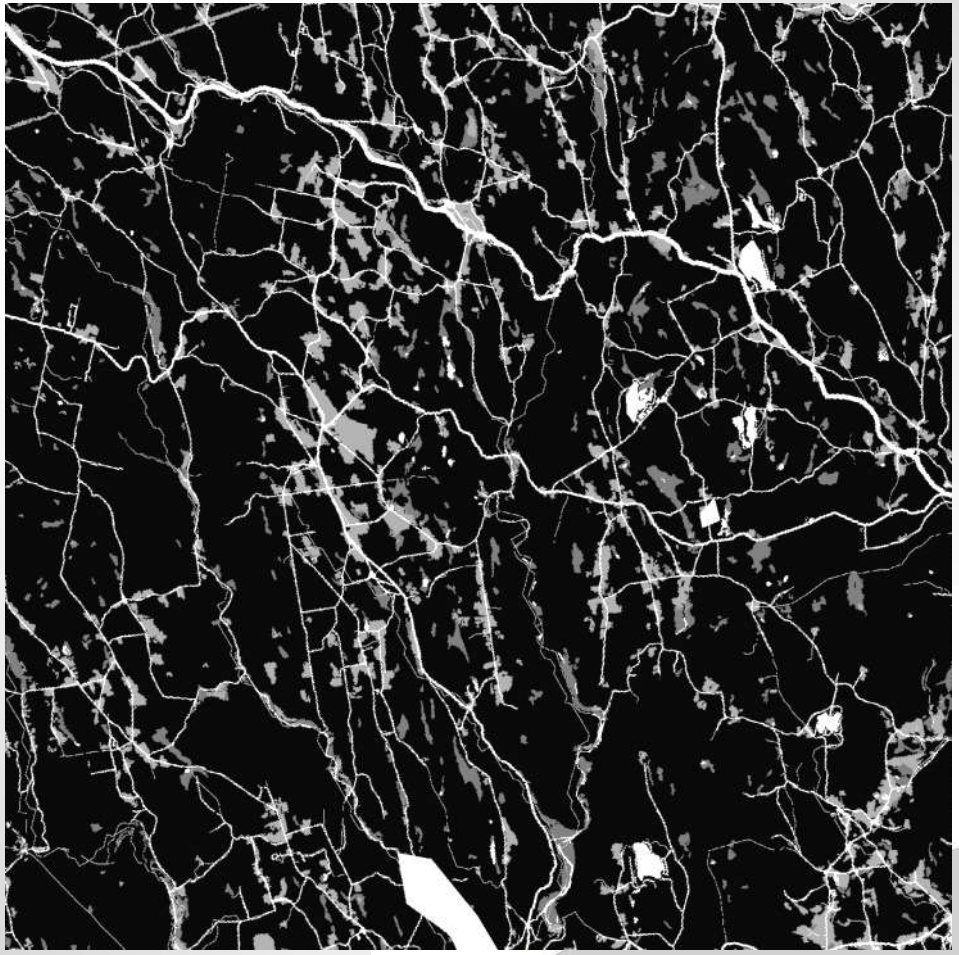
Example Land Classification Probability Map



From the New York 108 Case

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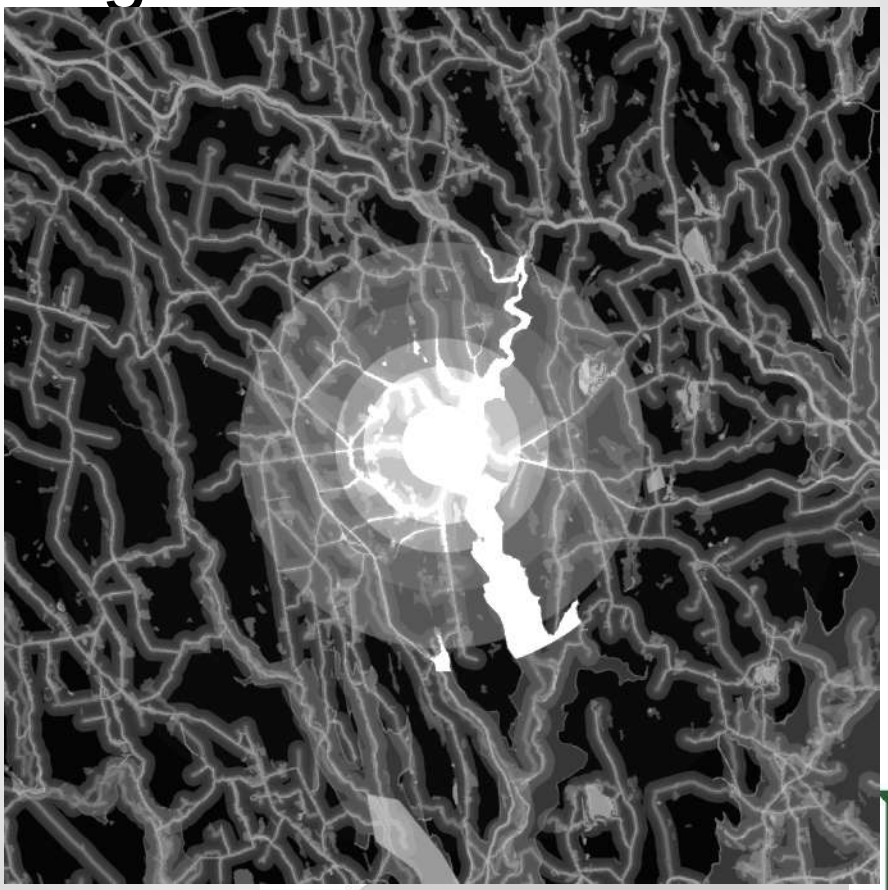
Combined Probability

- Average of all the probability maps, equally weighted.



From the New York 108 case

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Average Scores

Model	Average Score	Tests Completed
DELL	0.54…	26
Distance	0.52…	26
Elevation	0.59…	26
Linear Features	0.18…	26
Land Classification	0.23…	26

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Case by Case Scores

Case	Distance	Elevation	Linear Features	Land Classification	DELL
Arizona95	0.99354	-0.49825	0.915229	-0.047413	0.942662
Arizona01	-0.19774	-0.16843	-0.03983	0.95349	0.79786
Arizona03	0.94675	0.88205	0.97485	-0.07843	0.98671
NewYork108	0.99364	0.98085	-0.07907	-0.15934	0.98287
Avg Hiker	0.68408	0.29906	0.44279	0.16708	0.92753
Arizona02	0.64351	-0.42168	-0.0288	0.2041	0.35105
Arizona24	0.99676	0.98127	-0.09049	-0.37102	0.81521
Avg Dem	0.82014	0.27980	-0.05965	-0.08346	0.58313
Avg	0.7652	0.4258	0.38149	0.12455	0.80788

So far

- On average, combining the models does better than any of **our** individual models
- Elevation is the most accurate of **our** individual models.
- The BYU Motion Models have so far scored an average of .744

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Future Work

- ~~Providing GIS Layers for test cases.~~
- Run more test cases.
- Automated baseline models.
- Scripting support.
- Allow subjective consensus

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Citations

[1] http://www.nationalparkstraveler.com/2010/08/search-and-rescue-ops-cost-national-park-service-48-million-20086495

[2] http://www.odt.co.nz/news/national/38500/search-and-rescue-operations-cost-400000?page=0%2C1

[3] http://faculty.cs.byu.edu/~mike/mikeg/papers/LinGoodrichIROS2009.pdf

[4] Robert J. Koester 2008. *Lost Person Behavior*

[5] Elizabeth Sarow 2011. Determining Probability of Area for Search and Rescue using Spatial Analysis in ArcGIS 10. ESRI slides.

[6] Proportional Consensus spreadsheet. http://www.sarblog.info/proportional-consensus-method/.

[7] Rossmo, D. K. (1999). *Geographic Profiling* (1st ed.). CRC Press.

SAR*Bayes*: http://sarbayes.org

MapScore: http://mapscore.sarbayes.org

BYU WiSAR: https://facwiki.cs.byu.edu/WiSAR/index.php/Main_Page

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Further Reading

- Some cool BYU articles
  - L. Lin and M. A. Goodrich. A Bayesian Approach to Modeling Lost Person Behaviors Based on Terrain Features in Wilderness Search and Rescue. To appear in *Computational and Mathematical Organization Theory.*
  - M. A. Goodrich, B. S. Morse, C. Engh, J. L. Cooper, and J. A. Adams. Towards using Unmanned Aerial Vehicles (UAVs) in Wilderness Search and Rescue: Lessons from field trials. *Interaction Studies* , 10(3), pp455-481, 2009. Copy available on request.
  - M. A. Goodrich, B. S. Morse, Damon Gerhardt, J. L. Cooper, M. Quigley, J. A. Adams, and C. Humphrey. Supporting Wilderness Search and Rescue using a Camera-Equipped Mini UAV. *Journal of Field Robotics*, 25 (1-2), pp89-110, 2008. The paper is available for free from Wiley InterScience.
  - L. Lin and M. A. Goodrich. A Bayesian Approach to Modeling Lost Person Behaviors Based on Terrain Features in Wilderness Search and Rescue. *Proceedings of the 18th Conference on Behavior Representation in Modeling and Simulation.* Sundance, UT, USA. March 31-April 2, 2009. pp. 49-56.

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