Lognormal and Watershed Models of Lost Person Behavior

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Abstract

Wilderness searches consume thousands of man-hours and millions of dollars per year. Timeliness is critical. After 24 hours, survivability drops by about 20%. Good probability maps could greatly speed intensive searches.

MapScore (mapscore.sarbayes.org) provides a web-based portal for scoring, comparing, and improving models of lost person behavior – or any 2D probability map where ground truth is known.

Researchers receive case data and upload maps which are then scored according to the actual find location.

Cases come from the International Search & Rescue Incident Database (ISRID). MapScore now uses 300 of the thousands of available ISRID cases.

Wilderness Search and Rescue (WiSAR) is decades behind maritime search, and there are no theoretically sound tactical decision aids, in part because it lacks good probability maps. MapScore aims to change that.

Right now three universities are testing and refining their models. We describe the system and present preliminary results

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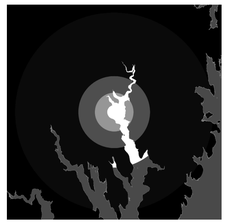
Static Models of Lost Person Behavior

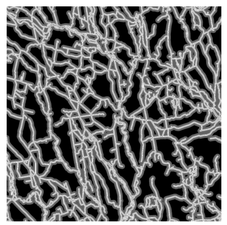
We can generate probability maps directly from Koester's (2008) statistical summary of the International Search and Rescue Incident Database. These statistical models are based on actual find location and assume that the lost person is **stationary** during the search. Sarow (2011) created ArcGIS models for Yosemite National Park. We modified them for MapScore.



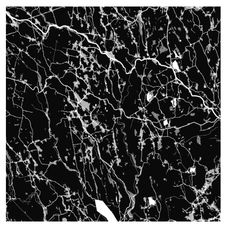
From the New York 108 Case

The image on the left combines two basic models: the Distance from Initial Planning Point (IPP) and the Elevation Change from (IPP). The Distance from IPP model depicts the 25%, 50%, 75%, and 95% distance rings from the IPP. In all the images , higher probabilities are brighter. The Elevation Change assigns different probabilities to- cells based on both distance from IPP and whether the cell is uphill, downhill, or at the same elevation as the last known point.

The Linear Features/Track Offset model creates distance buffers around the combined linear features in the search area – currently roads and rivers. Cells closer to the linear feature have a greater probability per cell than cells farther away from the feature.



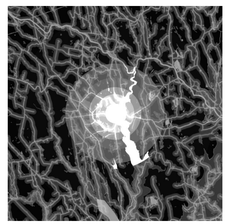
From the New York 108 Case



From the New York 108 Case

The Find Location model assigns different probabilities to different land types (forests, meadows, brush, water, etc.). ISRID reports terrain and vegetation for find locations. Sarow's models support buildings, campgrounds, ranger stations, and trails if available. So far we have not used these features.

Lastly, an equally weighted average is calculated , and reported as the DELL model (for Distance, Elevation, Landover, and Linear features.)

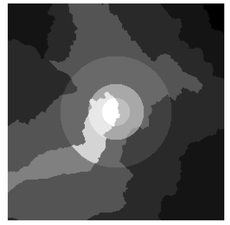


From the New York 108 Case

Watershed

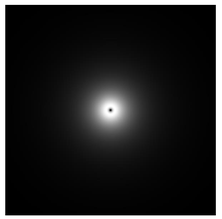
Because of the necessary data collection for each and reliance on ArcGIS, the previous models did not run very efficiently for a large number of test cases, and did not significantly outperform the simple ring distance model. As a result, we looked for simple, efficient improvements on the distance model.

Statistics from Doke (2012) shows that subjects tended to stay in the same watershed as the IPP. In this model, watershed boundaries were combined with the distance rings because just using watersheds did not significantly outperform the distance model.



From the Arizona 29 case

Lognormal



Category: Hiker, Dry Mountainous

Examining the find location statistics, it was found that the distance from the IPP followed a lognormal distribution, and the mean and standard deviation were calculated for each category (child, hiker, dimentia, etc.). Cases were then assigned maps based on the categorical information.

MapScore Rating System

The MapScore website lets researchers compare various WiSAR models on actual incidents from ISRID. This version has 300 U.S. cases (mostly AZ, NY, and Yosemite). Users are presented with a lost person scenario including last known position, elapsed time, and the characteristics of the lost individual. Based on this information, users create a probability map *by whatever means they* like, and upload a grayscale raster image (PNG format) . Images must match our bounding box (25 x 25 km centered on the IPP, with each pixel representing 5 x 5 m). These maps are uploaded to the portal and automatically scored using the actual find location.

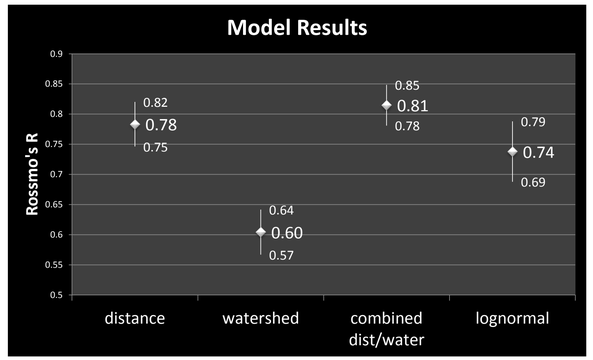
Scoring Metric

Our probability maps are scored using Rossmo's *R*, which ranges from -1 (bad) to 1 (good). Let r be the proportion of pixels with probability > that of the find location, and *R* rescales it to [-1,1] with a random map receiving a score of 0. A slight tweak ensures that uniform maps also receive a score of 0. Formally:

$$r = \frac{(n + \frac{m}{2})}{N} \text{ and } \mathrm{R} = \frac{.5 - r}{.5}$$

Where m is the number of pixels exactly equal to that of the find location.

Results



Future Work

One immediate drawback of the lognormal model is that if forces the probability that the subject will be found at the IPP to 0. From the ISRID data, 8.46% of the subjects *were* found at the IPP, driving scores down. To rectify this, we are taking probability given that the subject was not found at the IPP and combining it with the probability(for each category) of being found at the IP.

Another logical extension would be to combine the watersheds with the lognormal distance model, and compare to the combined watershed and distance ring maps.

Using elevation maps and the USGS National Land Cover dataset, least cost path models could also be created.

References

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