GeoProfile: Developing and establishing the reliability of a new geographic profiling software system

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Background and Hypothesis

The field of geographic profiling exists to help law enforcement locate serial offenders from their distributions of crime scenes (Canter, Coffey, Huntley, & Missen, 2000). Researchers have created predictive software designed to help law enforcement prioritize their investigations (Levine, 2004). However, law enforcement has yet to widely embrace geographic profiling (Paulsen, 2006). While other factors certainly apply, part of the problem may lie with the software itself. After reviewing the three major geographic profiling software systems, *Rigel Analyst*, *CrimeStat*, and *Dragnet*, it became clear that each exhibits one of two limitations: either the application is (a) too cost-prohibitive to purchase and implement or (b) too difficult and time consuming for everyday use by law enforcement. A new geographic profiling software system, *GeoProfile*, was designed to address these issues. It was predicted that *GeoProfile* will perform as accurately as existing geographic profiling software.

Development of GeoProfile

To address the specific weaknesses of the existing geographic profiling software, *GeoProfile* was designed around four core concepts: simplicity, speed, affordability, and accuracy.

Simplicity: *GeoProfile* was designed as a web-based application so anyone with an internet connection could access the software regardless of their operating system. Moreover, no files need to be downloaded by the user; as a result, the software can be updated without having to redistribute the program to every user.

GeoProfile uses a simplified work flow to increase ease-of-use; it was designed to require little or no training. To create a profile, the user adds each crime scene by entering the latitude-longitude coordinates or street addresses, along with any desired meta-data, into a form. The predictive probability map is updated automatically with each change to the profile. Furthermore, *GeoProfile* incorporates Open Street Maps, an alternative to Google Maps, so that a separate Geographic Information System (GIS) is not needed to apply the analysis to an investigation.

Speed: The simplified workflow and embedded mapping allow users to create and use a profile within minutes. One crime analyst reported creating a profile in eight minutes despite having never used *GeoProfile* before. Furthermore, users have the option of importing one or more series using a comma separated value (CSV) file.

Affordability: *GeoProfile* remains affordable through the use of license-free open source software components and services. Consequently, the overhead is limited to web server costs and the time it takes to maintain the server and software.

Accuracy: Because the core algorithm used by *GeoProfile* is the same as the one used by *CrimeStat* and *Dragnet*, *GeoProfile* is expected to preform with similar accuracy; this study tests that hypothesis.

After the design for *GeoProfile* was established, Jim English, an applications developer by profession, developed a prototype of the application to test the study's hypothesis. Upon completion of the study, Wesley English developed a stable version of *GeoProfile* for use by the law enforcement and research communities. The core algorithms remained the same as the prototype, but the user interface was redesigned to increase the usability and aesthetic quality of the software. Furthermore, the stable version implemented two distinct interfaces, one for law enforcement and one for researchers.

Method

The data used to test the reliability of *GeoProfile* were crime scene and home locations of 55 serial offenders from Baltimore County, Maryland.

Comparing *GeoProfile* to all three of the major geographic profiling applications would have produced a fuller picture of where *GeoProfile* ranks among the others in terms of accuracy. However, Rossmo denied a request to use *Rigel Analyst* in this study. Consequently, this study compares *GeoProfile* to *CrimeStat 3.1* and *Dragnet-K*.

The data set was analyzed by *CrimeStat*, *Dragnet*, and *GeoProfile*. Two measures of accuracy, *search cost* and *error distance*, were then measured and recorded for each series on all three applications. Search cost is defined as the percentage of the map searched before finding the actual home location of the offender (Rich & Shively, 2004). Error distance is defined as the straight-line distance from the predicted home location to the actual home location of the offender (Rich & Shively, 2004).

The scores for *GeoProfile* were then compared to the scores of *CrimeStat* and *Dragnet* using non-inferiority testing with the upper equivalence range defined a priori as 20% worse than the reference mean.

Results

GeoProfile was non-inferior to *CrimeStat* ($p = .00001$) and *Dragnet* ($p = .0023$) when search cost was used as a measure of accuracy. *GeoProfile* was non-inferior to *Dragnet* ($p = .000001$) when error distance was used as a measure of accuracy. *GeoProfile* was not non-inferior to *CrimeStat* ($p = .0556$) when error distance was used as a measure of accuracy. However, a significant difference between the mean error distances of *GeoProfile* and *CrimeStat* was not found ($p = .3372$). In this instance, even the established applications were not equivalent. *Dragnet* was also not non-inferior to *CrimeStat* ($p = .6332$) when error distance was used as a measure of accuracy, and a significant difference between the mean error distances of *Dragnet* and *CrimeStat* was found ($p = .0022$). See Table 1 for a succinct listing of the above non-inferiority tests. Figure 1 and Figure 2 illustrate that *GeoProfile* follows the same pattern of performance at each increment of the data set as *CrimeStat* and *Dragnet* on both sets of accuracy measures.

Discussion

GeoProfile was shown to be non-inferior to at least one of the major geographic profiling applications in each category of accuracy measures. Consequently, the hypothesis that *GeoProfile* performs as accurately as the established software systems is supported by these results.

Including *Rigel Analyst* in the study would have provided a clearer picture of where *GeoProfile* stands in terms of accuracy in relation to all three of the major geographic profiling applications. Additionally, a larger sample that included series from multiple jurisdictions around the country would have strengthened the results by eliminating any confounding variables related to Baltimore County.

The introduction of *GeoProfile* has two potential implications: First, *GeoProfile* could play an important role in advancing the field of geographic profiling by decreasing the amount of time and effort required to do research. Furthermore, *GeoProfile* allows another researcher the opportunity to experiment with the core strategies of geographic profiling, something that is limited to those with access to the inner workings of a program. Second, *GeoProfile* could lead to the increased use of geographic profiling by law enforcement as the affordability and simplicity of *GeoProfile* may appeal to investigators who would be willing to implement geographic profiling if it were inexpensive and easy to use.

Note to Geographic Profiling Researchers

Any academic interested in using *GeoProfile* in their research may contact Wesley English at wesleyenglish@gmail.com to request an account.

Special Thanks

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Table 1

Non-Inferiority Tests

Accuracy Measure	Non-Inferior	P-Value
Search Cost		
CrimeStat	Yes	.00001
Dragnet	Yes	.0023
Error Distance		
CrimeStat	No	.0556
Dragnet	Yes	.000001

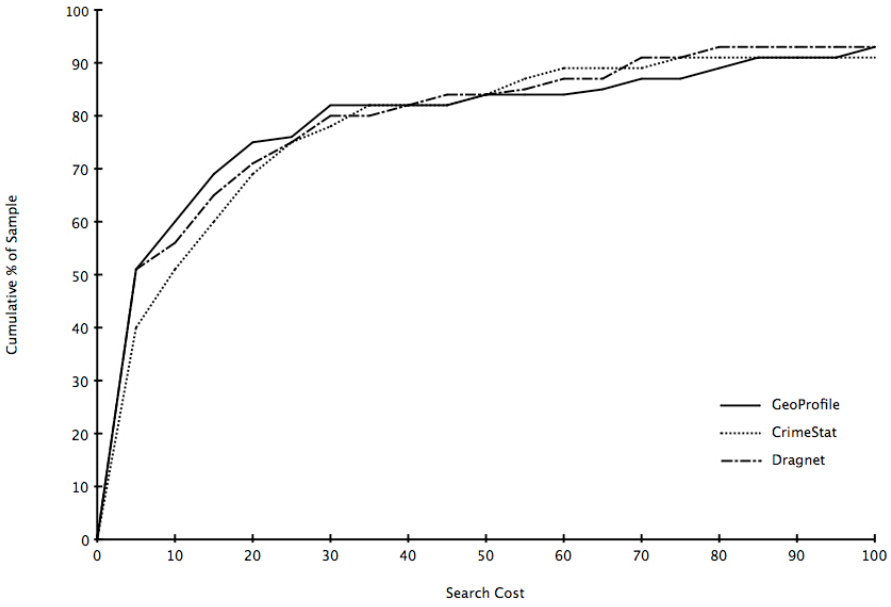

Figure 1. Cumulative search cost percentages produced by each application.

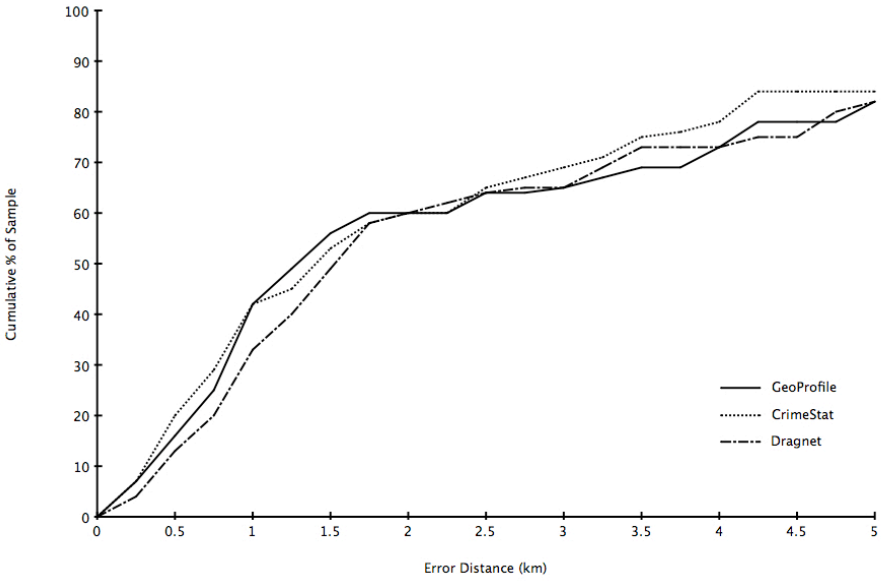

Figure 2. Cumulative error distance percentages produced by each application.