Crime-Avoiding Routing Navigation

Rishe, Naphtali; Sadjadi, Masoud; and Adjouadi, Malek

Abstract: ***Extensive prior work has provided methods for the optimization of routing based on the criteria of travel time and/or on the cost of travel and/or the distance traveled. A typical method of routing involves building a graph comprised of street segments, assigning a normalized weighted value to each segment, and then applying the weighted-shorted path algorithm to the graph in order to find the best route. Some users desire that the routing suggestion include consideration pertaining to the reduction of risk of encountering violent crime. For example, a user desires a leisure walk via a safe route from her hotel in an unknown city. Here we present a method to quantify such user preferences and the risks of encountering crime and to augment the standard routing methods by giving weight to safety considerations. The proposed method's advantages, in comparison to other crime-avoidance routing algorithms, include weighing crime types with respect to their potential detrimental value to the user, with temporal qualification and quantification of crime and its statistical aggregation at the geographic resolution down to a city block.***

Index Terms: Crime-avoidance, Crime classification, Crime data, Crime impact weighting, Multi-parametric routing, Navigation, Routing, Spatiotemporal analysis of crime

1. Introduction

Previous research [1-9] has developed methods for the optimization of routing based on the criteria of travel time and/or on the cost of travel and/or the distance traveled. Routing can be in various modalities, such as by car, on foot, by bicycle, via public transit, or by boat. A typical method of routing involves building a graph comprised of street segments, assigning a normalized weighted value to each segment, and then applying the weighted-shorted path algorithm to the graph in order to find the best route.

Routing can take into account preference parameters in addition to time and distance. For example, routing suggestions can include c consideration pertaining to the reduction of the risk of encountering violent crime. For example, a user desires a leisure walk via a safe route from her hotel in an unknown city. Here we present a method to quantify such user preferences and the risks of encountering crime and to augment the standard routing methods by giving weight to said safety considerations.

Galburn *et al.*[4] have utilized crime data to optimize the safety aspect of navigation within a city. Their case study involved urban crime data from Illinois and Pennsylvania. Their proposed risk model for the street network within a city facilitated estimating probabilities of criminal incidents that the traveler may encounter on any road segment. In their approach, the same importance is assigned to the path traversal time and the crime incident risk. Their method solves a dual-objective shortest-path problem.

Here we presented an improved method to co-optimize crime avoidance with other criteria. The proposed method's advantages, in comparison to other crime-avoidance routing algorithms, include weighing crime types with respect to their potential detrimental value to the user, with temporal qualification and quantification of crime and its statistical aggregation at the geographic resolution down to a city block.

The following figure shows traditional routing optimizing the time and/or distance.

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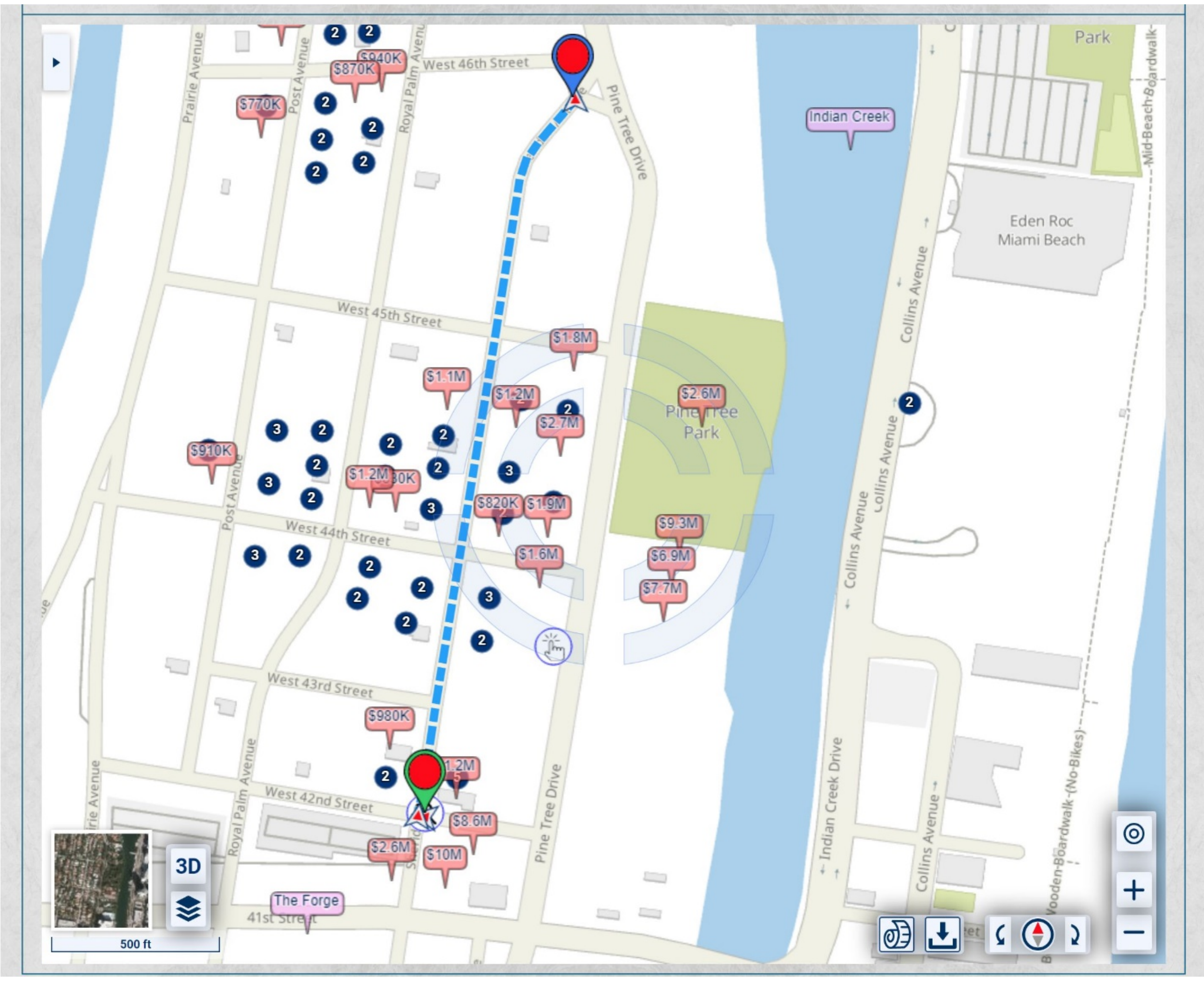

Figure 1: Routing that optimizes time and/or distance

Here we present an improved method to co-optimize crime avoidance with other criteria. The proposed method's advantages, in comparison to Galburn [4] and the other crime-avoidance routing algorithms, include:

(1) weighing crime types with respect to their potential detrimental value to the user,

(2) with temporal qualification,

(3) quantification of crime and its statistical aggregation at the geographic resolution down to a city block, and

(4) evaluation of the crime detriment to the user in each segment by considering the needs, exposure, and preferences of the user rather than merely considering the general crime incidence statistics. For example, violent crime committed outdoors have a higher impact, and severe violence, such as homicide in the street, have the highest impact. Crimes without a direct unrelated victim, such as code violations or embezzlement, have no impact on travelers. Pick-pockets have an impact on travelers in walking mode but minimal impact on travelers by car. Non-statutory rape may be of high concern to a woman walking alone. For each type of traveler and travel modality, the present method provides default formulas for the evaluation of crime detriment in each segment. Additionally, the user may modify the formula by assigning greater or lesser importance to various types of crimes.

2. Methodology

In order to quantify crime risks for each street segment, we count police reports that occurred close to that segment during a set period of time, e.g., a particular year of reference, counting only violent and property crimes of the type that would directly affect the traveler (e.g., exclude domestic violence, exclude insider trading, exclude code violations, exclude statutory rape) and can further assign weights to various crime crimes based on the impact it may have in the traveler. The following is an example of a query to a crime database for an area in mid-Miami Beach.

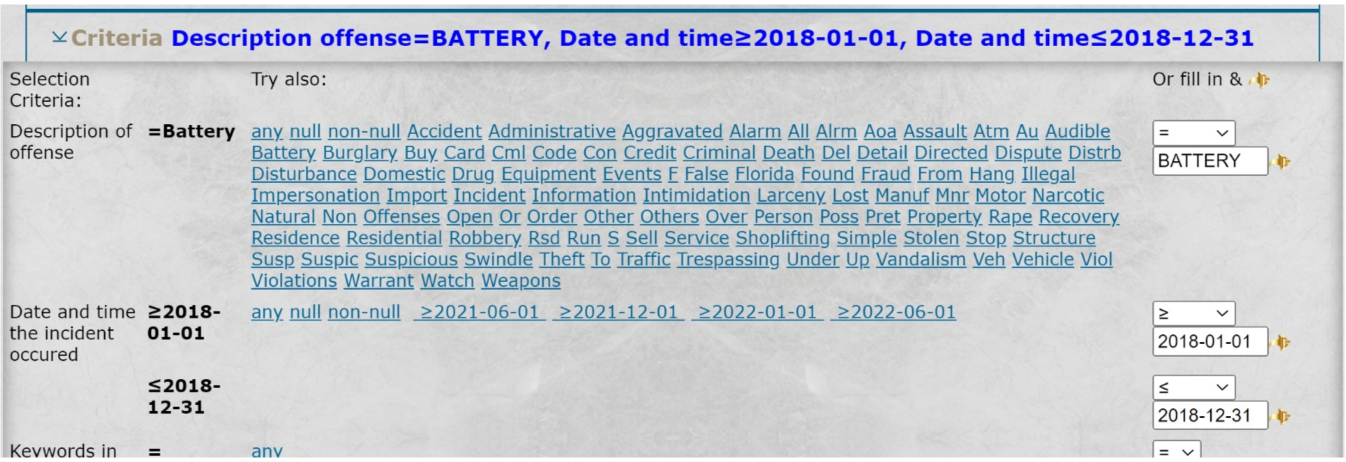

Figure 2: A sample query to a crime database

The above query may result in a set of incidents shown in the following map.

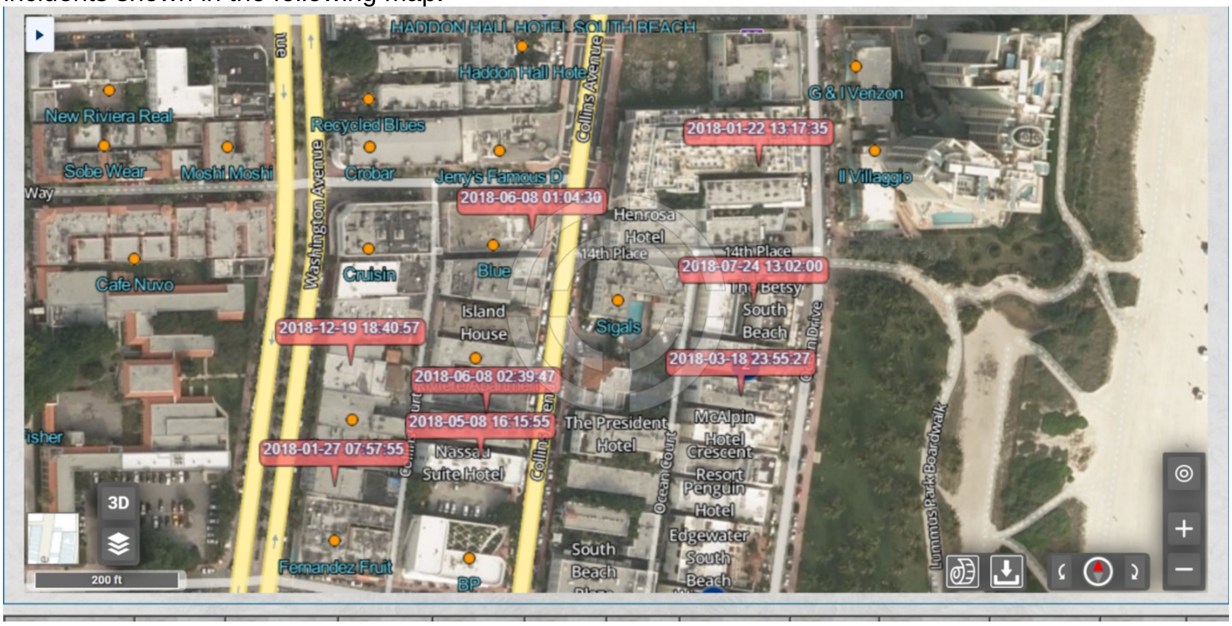

Figure 3: Map of incidents

The following is a tabular output of the query:

Case number	Description of offense	Date and time the incident occured	Reported	Address where the incident occured	Police district	Clearance code description as reported by Officer	Business name involved in incident	Signal code description	Victim type description	Victim name(s)	Suspect name(s)	Arrestee name
MBc2018-00120592	Assault Or Battery OF LAW ENFORCEMENT OFFICERS, FIREFIGHTERS, EMERGENCY MEDICAL CARE PROVIDERS, PUBLIC TRANSIT EMPLOYEES Or AGENTS, Or Other SPECIFIED OFFICERS; RECLASSIFICATION OF OFFENSES; MINIMUM SENTENCES	≤2018-12-19 18:40:57≥		1425 WASHINGTON AVE		APPROVED						
MBc2018-00054670	BATTERY-FELONY Battery	≤2018-05-18 06:48:59≥		600 ESPANOLA WAY		Closed						
MBc2018-00010991	BATTERY-FELONY Battery	≤2018-01-27 07:57:55≥		1409 WASHINGTON AVE		Closed No SOLVABILITY						
MBc2018-00061490	BATTERY-FELONY Battery	≤2018-06-08 02:39:47≥		1420 COLLINS AVE		1 - Closed N- A						

Figure 4: Report of incidents

The mid-Miami Beach area of the previous example did not have homicide reports during the sampling period. To see homicide reports, which should be considered with a higher weight than battery, we need to query an area further west:

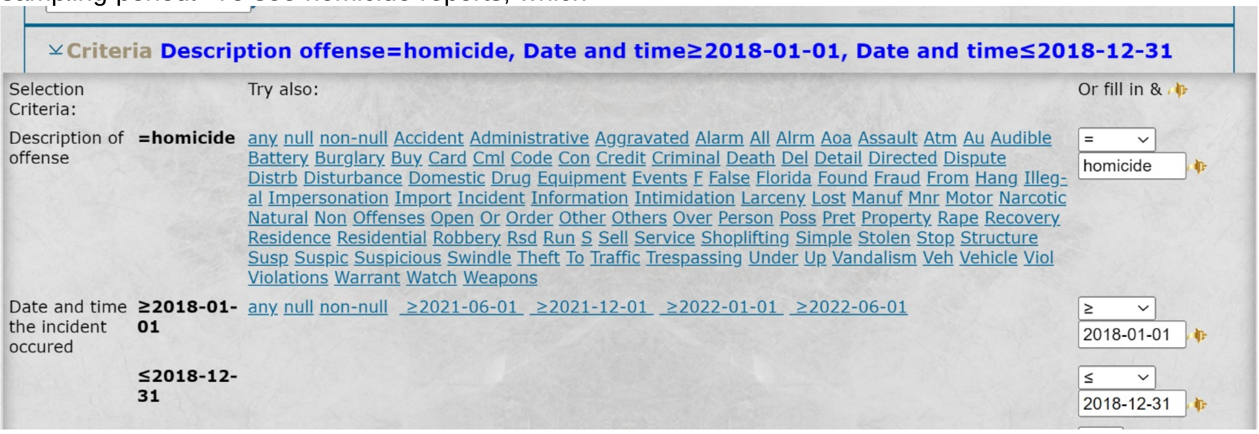

Figure 5: Homicide query

The results are shown in the following map and table.

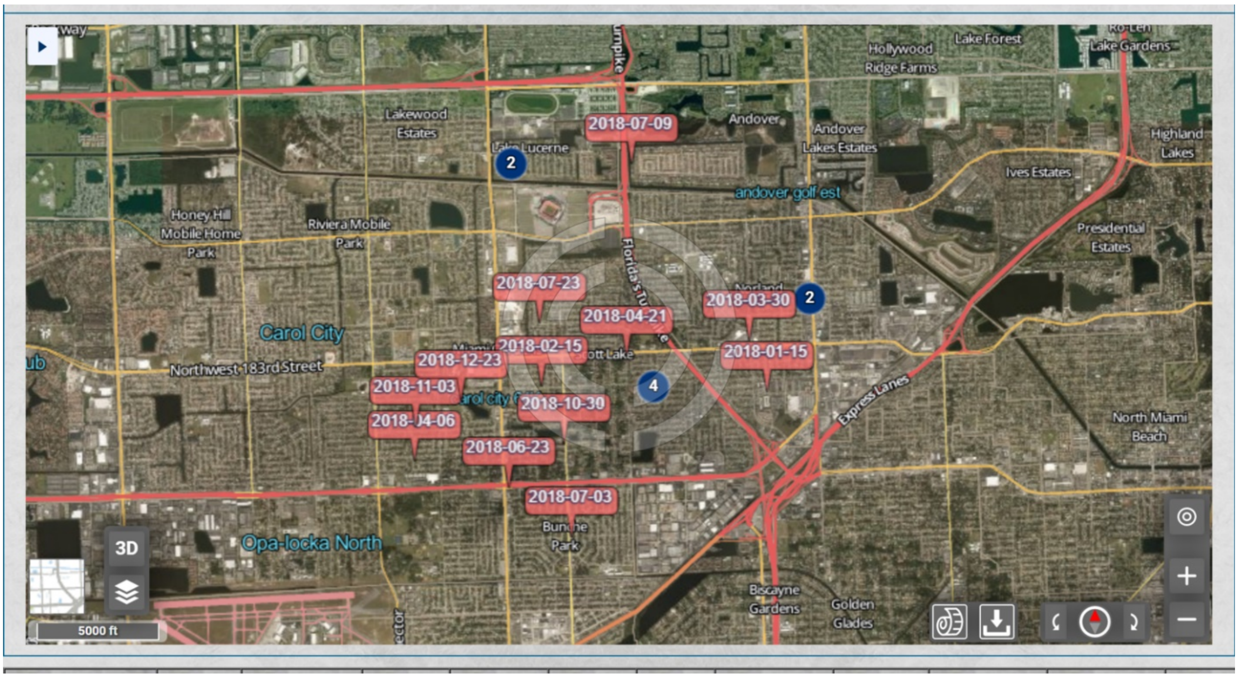

Figure 6: Map of homicide incidents

links to locations & details	Case number	Description of offense	Date and time the incident occured	Reported	Address where the incident occured	Police district	Clearance code description as reported by Officer	Business name involved in incident	Signal code description	Victim type description	Victim name(s
1: 0.2±0.31 miles	MGc20-18007-150	Information - Accident Traffic HOMICIDE	≤2018-04-21≥		18249 NW 17TH AVE NW 183RD ST	Zone 11					
2: 2107'	MGc20-18009-665	Information - Accident Traffic HOMICIDE	≤2018-05-28≥		1621 NW 179TH ST	Zone 11					
3: 2883'	MGc20-18016-121	HOMICIDE-MURDER	≤2018-09-03≥		1300 NW 180TH TER	Zone 11					
4: 2890'	MGc20-18020-205	HOMICIDE-MURDER	≤2018-11-02≥		17701 NW 15TH CT	Zone 11					
5: 3137'	MGc20-18008-225	HOMICIDE-ATTEMPTED MURDER	≤2018-05-07≥		17730 NW 13TH CT	Zone 11					
6: 3383'	MGc20-18013-358	HOMICIDE-MURDER	≤2018-07-23≥		18700 NW 23RD AVE	Zone 31					
7:	MGc20-	HOMICIDE-	≤2018-		2335	Zone					

Figure 7: Table of homicide incidents

The importance of querying for only specific types of crime (and weighting them) is demonstrated by the following query, whose results are mostly crimes that have no bearing on the prospective traveler.

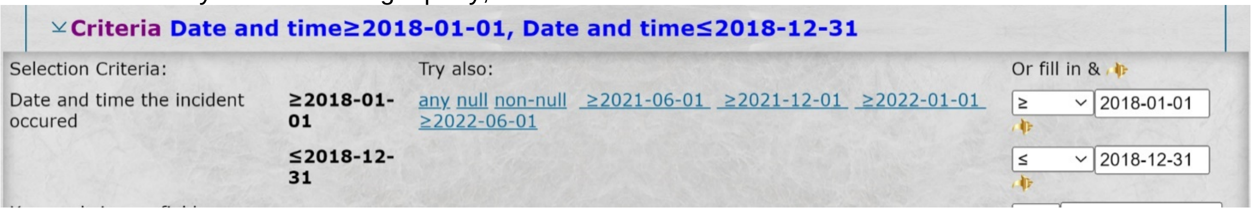

Figure 8: Query not restricting crime types

Figure 9: Map of the output of a query not restricting crime types

Case number	Description of offense	Date and time the incident occured	Reported	Address where the incident occured	Police district	Clearance code description as reported by Officer	Business name involved in incident	Signal code description	Victim type description	Victim name(s)	Suspect name(s)	[illegible]
MBc2018-00119260	PROHIBITED ACTS; PENALTIES	≤2018-12-15 01:13:19≥		200 30TH ST		Pending						
MBc2018-00116267	Larceny - Under $50.00 (+ ATT.)	≤2018-12-05 01:09:38≥		200 30TH ST		1 - Closed N- A						
MBc2018-00079230	Larceny - Under $50.00 (+ ATT.)	≤2018-08-01 10:52:39≥		200 30TH ST		Closed No SOLVA-BILITY						
MBc2018-00064680	FRAUD-ILLEG USE Credit CARDS	≤2018-06-18 10:56:58≥		2940 COLLINS AVE		Closed						
MBc2018-00115181	Larceny - $50 To $200	≤2018-12-01 08:53:53≥		2940 COLLINS AVE		Closed No SOLVA-BILITY						
MBc2018-00109397	MUNICIPAL ORDINANCE Viol	≤2018-11-10 12:32:44≥		2940 COLLINS AVE		Closed No SOLVA-BILITY						
MBc2018-00102292	FORCIBLE Rape COMMITTED	≤2018-10-18 14:46:55≥		2940 COLLINS AVE		APPROVED						
MBc2018-00118987	Assault AGG	≤2018-12-14 02:29:59≥		2940 COLLINS AVE		REVIEW						
MBc2018-00038646	Criminal MISCHIEF; PENALTIES; PENALTY FOR MINOR	≤2018-04-04 11:20:39≥		220 30TH ST		Closed						
MBc2018	BURGLARY	≤2018-04		[illegible]		Open						

Figure 10: Tabular output of a query that does not restrict crime types, including crimes irrelevant for the traveler, e.g., credit card fraud

Turning back to routing, the following is a route optimizing travel time, which traverses segments where relevant crimes have occurred during the sampling period:

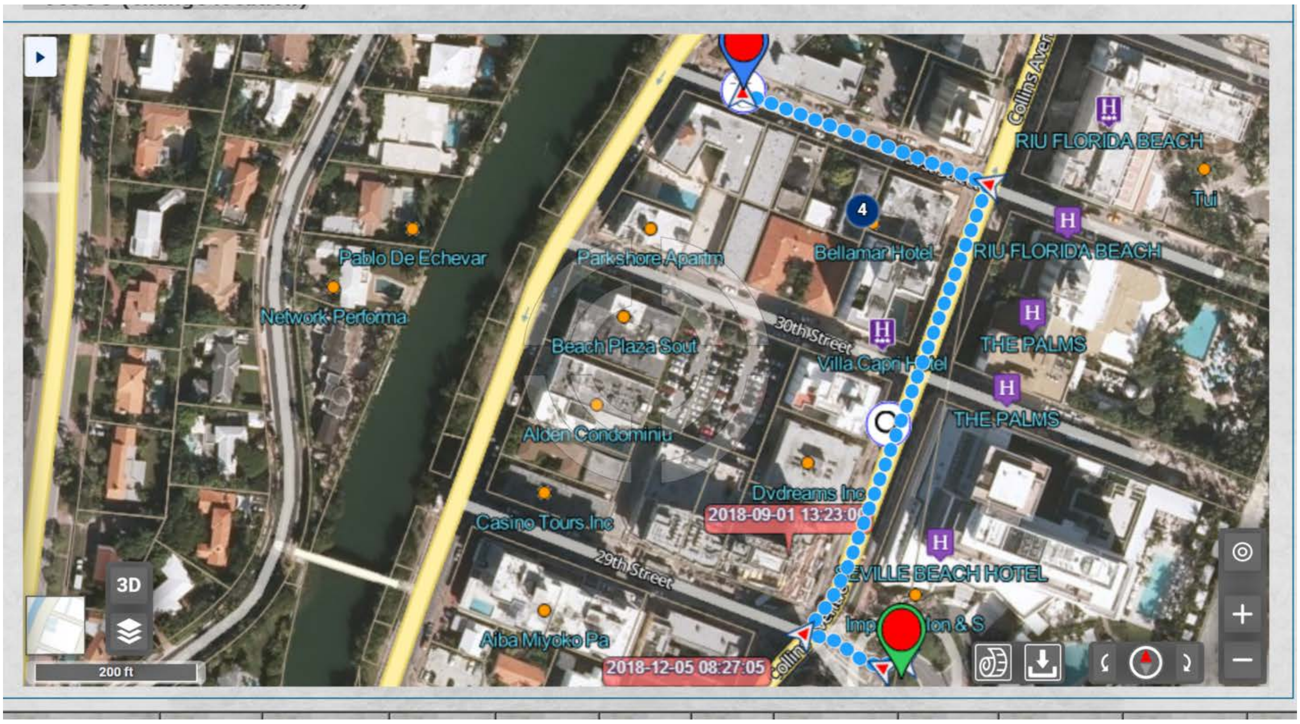

Figure 11: Time-optimized routing path, going through segments with higher crime potential

By co-optimizing the walk duration and crime encounter probability reduction, we get a slightly different route:

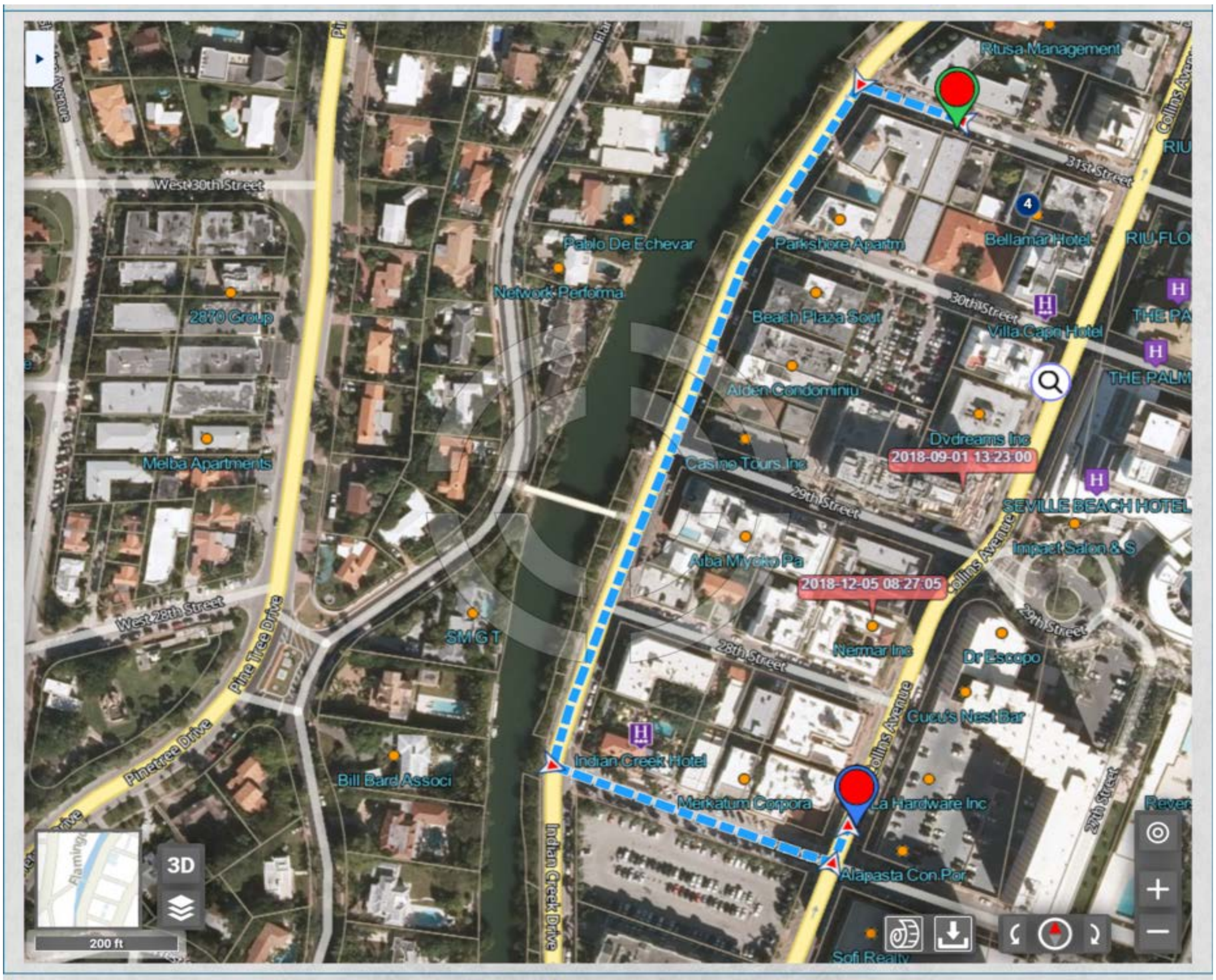

Figure 12: Routing co-optimizing time and crime avoidance

The routing may be different based on the mode of walking or transportation:

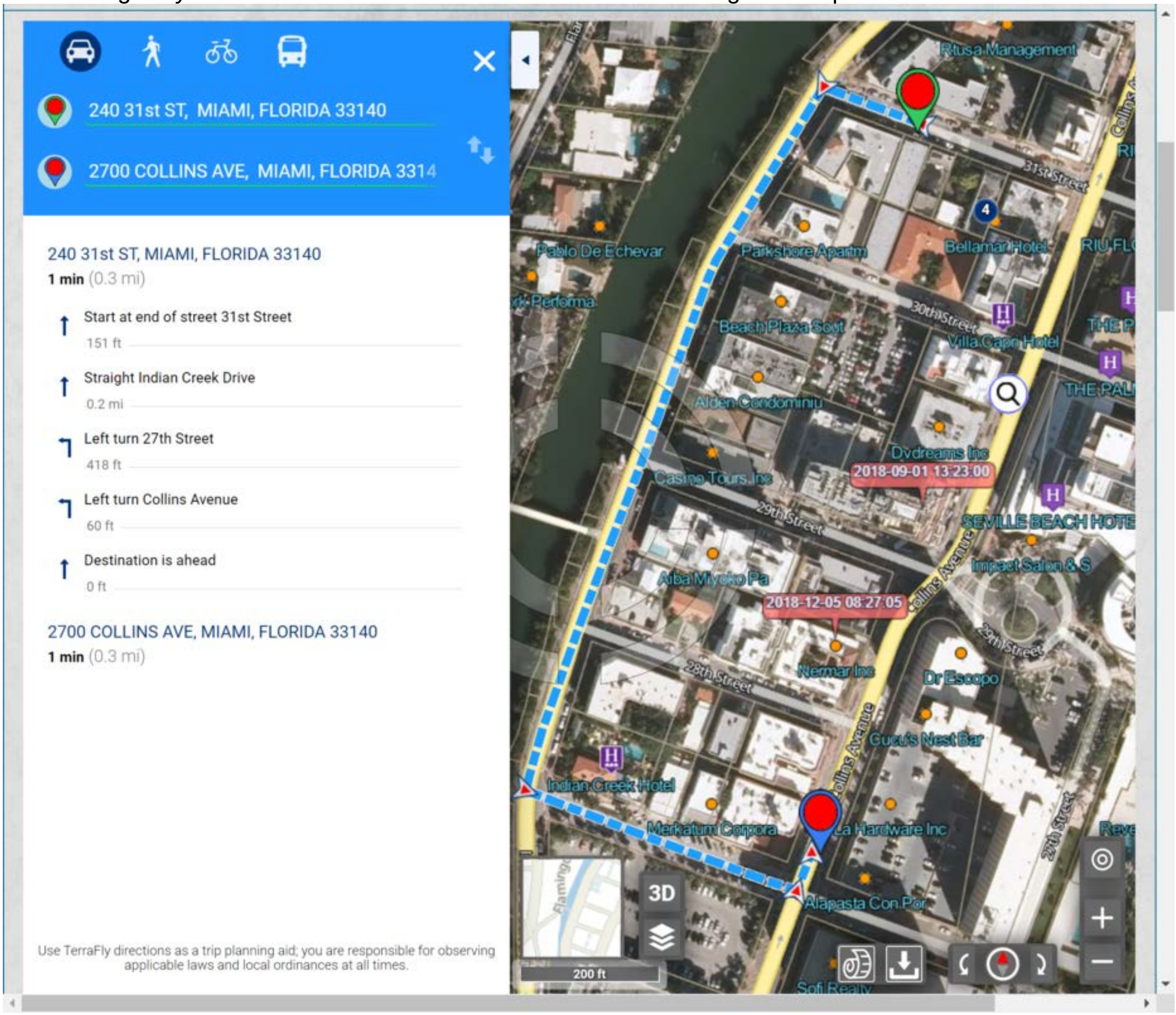

Figure 13: Time-optimized routing path, going through segments with higher crime potential, for various transportation modalities

The relative importance of time, cost of travel, and crime avoidance can be determined by the user utilizing a prior-art technology of weight selection triangle: a touchable triangle allows the user to assign importance weights to three interrelated decision optimization objectives using a single gesture [Oliver Ullrich, Naphtali Rishe, Daniel Luckerath. U.S. Patent US10061501B2 “User Interface for Co-Optimizing Weight Factors” issued on: August 28, 2018]:

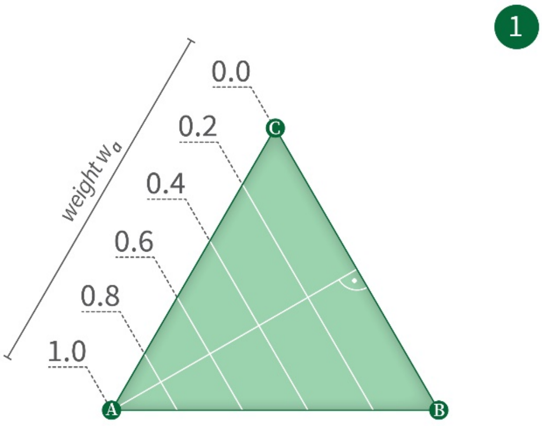

Figure 14: A weighting triangle with values along one side

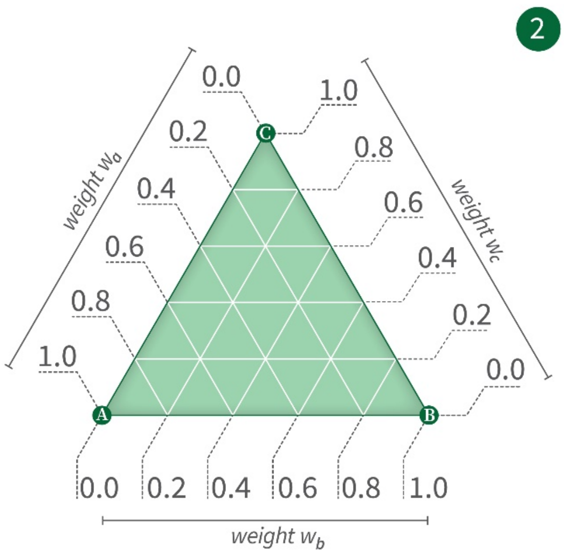

Figure 15: A weighting triangle with weighting values along all three sides

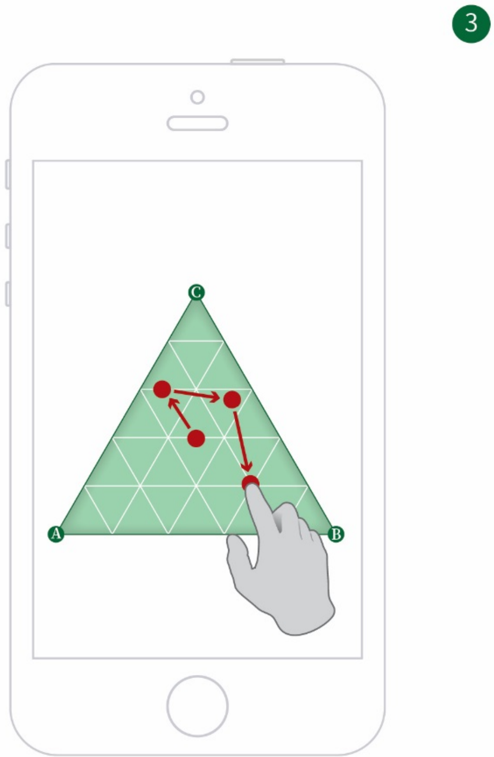

Figure 16: A smart device with the weighting triangle displayed thereon, showing a user selecting different weighting points

Applying said prior-art method to the herein proposed weighting selection problem, three objectives (*A=time*, *B=cost of travel*, and *C=crime avoidance*) are presented in a triangular fashion on a touch screen. Sub-figure 1 shows the underlying principle of the establishment of a single weight w_A for Objective *A*; Sub-figure 2 combines three objectives into a single triangle, allowing for the establishment of a tri-variable weight function *(*w_A*,* w_B*,* w_C*).* By applying a finger gesture, the user moves an indicator freely inside the triangle (see Sub-figure 3). The position of the indicator establishes a tri-variable weight function, which in further steps, is then used as input for a co-optimization algorithm. When the user is satisfied with the established weights, she indicates this, e.g., by pressing a touch screen button labeled “Go.”

Availability of Data and Materials

The data used in this work is available at http://terrafly.com. The geospatial data sets used in case studies to illustrate the method proposed herein can be provided by the corresponding author with appropriate arrangements.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

Conceptualization: Rishe; Methodology: Rishe and Adjouadi; Investigation: Rishe, Sadjadi, and Adjouadi; Writing: Rishe and Sadjadi; Funding acquisition: Rishe, Sadjadi, and Adjouadi. All the authors of this paper concur with its content and consent to its publication.

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