PASSAGE: A Travel Safety Assistant with Safe Path Recommendations for Pedestrians

Matthew Garvey
College of Computing
Georgia Institute of Technology
Atlanta, GA 30332, USA
mgarvey6@gatech.edu

Meghna Natraj
College of Computing
Georgia Institute of Technology
Atlanta, GA 30332, USA
mnatraj@gatech.edu

Nilaksh Das
College of Computing
Georgia Institute of Technology
Atlanta, GA 30332, USA
nilakshdas@gatech.edu

Bhanu Verma
College of Computing
Georgia Institute of Technology
Atlanta, GA 30332, USA
bhanuverma@gatech.edu

Jiaxing Su
College of Engineering
Georgia Institute of Technology
Atlanta, GA 30332, USA
Jiaxingsu@gatech.edu

Abstract

Atlanta has consistently ranked as one of the most dangerous cities in America with over 2.5 million crime events recorded within the past six years. People who commute by walking are highly susceptible to crime here. To address this problem, our group has developed a mobile application, PASSAGE, that integrates Atlanta-based crime data to find "safe paths" between any given start and end locations in Atlanta. It also provides security features in a convenient user interface to further enhance safety while walking.

Author Keywords

Safe Paths; Safe Navigation; Bi-objective Path Optimization; Pulse Algorithm

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces; G.2.2 [Discrete Mathematics]: Graph Theory

Introduction

Historic crime data allows general predictions of crime hotspots, and also making specific predictions such as those based on implicit modus operandi of criminals [6]. Future crime predictions can even be made using mathematical models accompanied with sentiment analysis of posts made on social media platforms like Twitter [5]. Our

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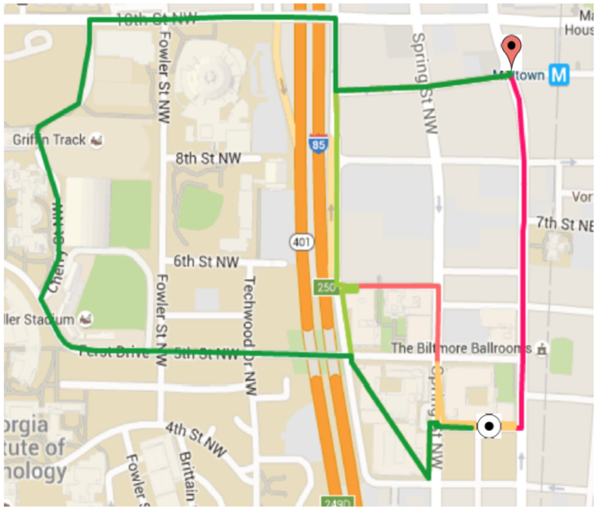


Figure 1: Paths recommended by PASSAGE

approach is to recommend safe paths to a user that minimizes crime risk as well as distance. PASSAGE also allows the user to share their current location with a friend while walking, and has a "safe mode" (see Figure 2) that allows the user to relay a distress signal to their friend with minimal interaction with the system (just by lifting a thumb from the screen).

Case Illustration

Alice wants to walk from Midtown MARTA Station (red marker in Figure 1) to Tech Square (black dot in Figure 1). She uses PASSAGE to see which are the safe routes available to her. The shortest route in this case is not however the safest, and is shown in pink. The safest route is shown in green. Intermediate dominant routes are also shown that offer the user a trade-off between risk and distance.

Implementation

Data

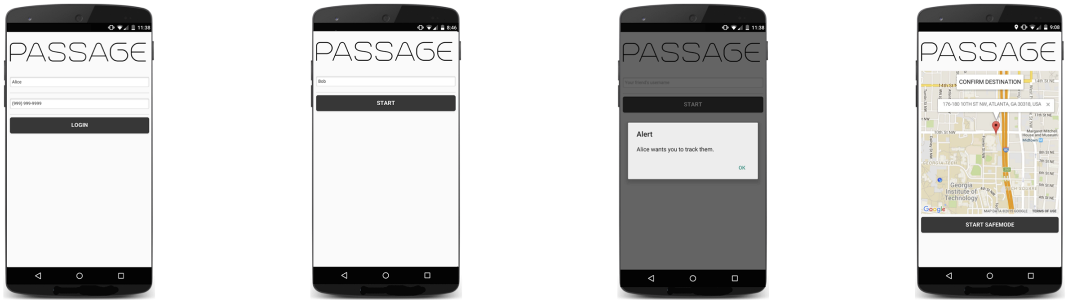
PASSAGE utilizes historic crime data available on the Atlanta Police Department website [1]. Map data for Atlanta was obtained from Mapzen Metro Extracts website in OpenStreetMap format [2]. We then used the osm4routing package to convert the map data to a graph of nodes and edges [3].

Crime Risk

Our strategy is to assign each edge in G, the graph of Atlanta, 48 distinct risk values - one for each 30-minute interval of the day. This accounts for the fact that some location may be safe during daytime but unsafe at night. The risk values of edges at time t are computed from the risk values assigned to the nodes of G for the 30-minute time window W that contains t. A given crime-node C that occurred in W was distributed using a gravity model to all nodes in G that are within 400m of C. For every window W, we aggregated the risk score for every node in G and propagated the risk measures to the edges of G.

Safe Paths

PASSAGE finds the optimal routes using the pulse algorithm [4]. This optimizes a bi-objective function B that is composed of a distance function D and a risk function R. $D(X)$ evaluates to the sum of the distances along all edges of a path X. $R(X)$ evaluates the sum of the risk values over all edges in X. A path X optimizes B if there is no other path Y that has lower risk and lower distance than X. The goal is then to aggregate a series of such optimal paths that together form a dominant set Z. The pulse algorithm recursively examines the entire search space of G to find all paths that are in Z. The algorithm gains efficiency by aggressively pruning partial paths that cannot result in a dominant path.



Alert

Alice wants you to track them.

OK

Alice and
Bob login

Alice requests
Bob to track her

Bob receives
a notification
from Alice

Alice confirms
her destination

Passage

Alice seems to be in distress. Consider calling them to make sure they are safe!

CALL ALICE

The algorithm offers Alice
multiple routes which
range from shortest
(pink) to safest (green)

Alice starts
“safe mode” and
places her thumb
on the screen

Bob will be notified if Alice
removes her thumb,
signaling distress

Figure 2: User Interface

	Mean
$D(LRP)$ / $D(SDP)$	1.13
$R(SDP)$ / $R(LRP)$	1.58

Table 1: Trade-off Analysis

Evaluation

Runtime Analysis

We generated 100 node pairs uniformly with replacement from a bounded box region of 3 sq. km in Midtown, Atlanta and found that the system took an average of 1.2s to return the dominant set of paths between the node pairs. This runtime is sufficiently fast to make the system practically usable while walking.

Trade-off Analysis

To evaluate the trade-off for using the application, we determined the mean ratio between the distances of the least-risk path (LRP) and the shortest-distance path (SDP) for the 100 node pairs, and correspondingly, the ratio between the risks of SDP and the LRP (Table 1). We found that going from SDP to LRP increases the distance but there is a sharper decrease in risk, making the trade-off worthwhile.

Conclusions and Future Work

We have developed an application that is effective in real-time in finding safer paths for walking, with significant decrease in risk. The application further augments safety by letting the user share their location while walking and also send distress signals in case of emergency.

Looking forward, we plan to modify the implementation of the pulse algorithm on the back-end to improve performance. On the front-end, we wish to allow the user to select a path and then offer a set of directions for the selected path, which will enhance the user experience. We also plan to provide a mechanism for the user to examine the risk and distance of each path in the dominant set. This will convey information more clearly to the user and help them in making a better decision about which path to take.

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