SAFEST PATHS FOR WOMEN IN CLUJ-NAPOCA

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Introduction

Urban safety for women represents a critical societal concern, with direct implications for mobility and quality of life. In this context, UrbanPathfinders is a mobile application designed to generate safe routes for women by leveraging modern technologies such as Machine Learning (ML) and geospatial analysis. This paper presents the system architecture of the application, the methodology used to identify safe routes, and the results obtained from initial testing.

Objective

Succinctly communicate UrbanPathfinders value proposition—delivering AI-enhanced, A*-powered walking routes that prioritize safety, air quality, and efficiency—by highlighting its real-time data integration, personalized recommendation engine, and privacy-first architecture, and to drive engagement through a clear call-to-action (e.g., QR code or download link).

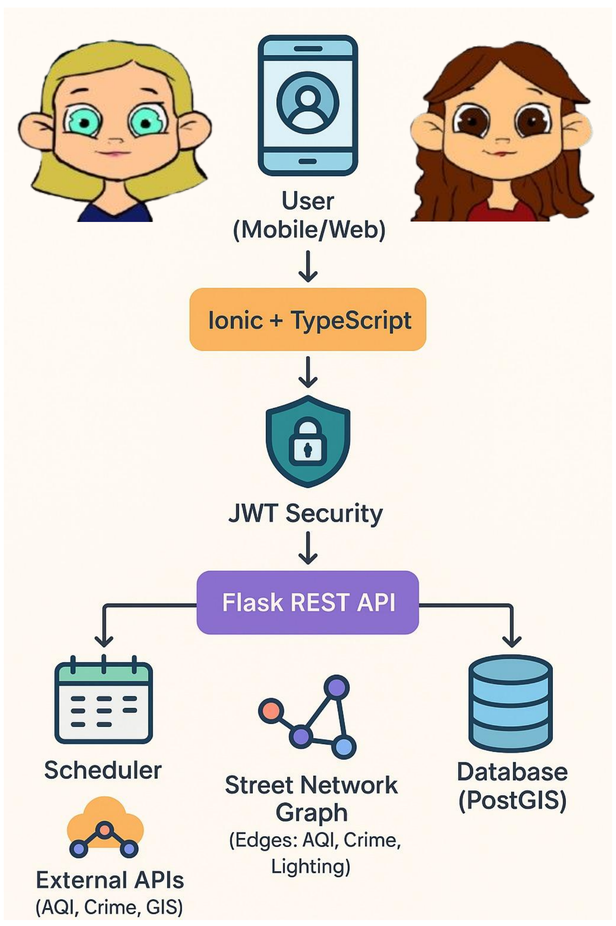
Related work

Researchers have also explored combining smartphones with wearable IoT devices for women's safety. Gehani and Ponnusamy (2024) describe a comprehensive AI-based women's security system involving a smart wearable (e.g. a device worn like a pendant or on clothing) connected to a mobile app [1]. Their design uses sensors like a microphone, heart-rate monitor, and accelerometer to detect signs of an attack or panic, for instance, voice recognition to detect a scream, elevated pulse, or sudden movements [1]. Upon detecting danger, the system would automatically activate a built-in electric shock module to disorient the attacker (a form of immediate self defense), while simultaneously sending the victim's location and an emergency alert to her trusted contacts and the police [1]. This study, published as a book chapter in Impact of AI on Advancing Women's Safety, illustrates the inventive ways AI and hardware can be integrated for personal protection.

Methodology

UrbanPathfinders furnishes a mobile application that computes optimal walking routes by balancing three primary criteria: air quality, travel time, and nighttime safety—especially tailored for women. The app comprises a TypeScript/Ionic front end and a Python backend incorporating AI-driven pathfinding and recommendation modules.

System Architecture



Route Computation Algorithm

Graph Modeling. Each street segment is an edge in a weighted graph; intersections (or sensor midpoints) are nodes. Edge weights combine time, pollution, and safety as:

$$wij = \alpha\ tij + \beta\ pij + \gamma\ sij,$$

where:

- tij = estimated traversal time,
- pij = normalized pollution level,
- sij = safety risk score

(higher for poorly lit or high-incident segments),

- α, β, γ = user-adjustable coefficients.

A Search with Custom Heuristic. We employ the A algorithm using a heuristic $\hbar(n)$ that estimates remaining composite cost based on straight-line distance ($d$euclid), expected AQI, and anticipated safety:

$$\hbar(n) = \alpha\ \tilde{d}\ \text{euclid}\ (n, \text{goal}) + \tilde{\beta}\ \text{AQIest} + \tilde{\gamma}\ s\text{est},$$

designed to be admissible and thereby guarantee optimality. A lightweight neural network (PyTorch) predicts a user satisfaction score for the top-k A candidates:

- Training data: Anonymous feedback ratings from beta testers.
- Features: total distance, mean AQI, count of dark segments, elevation gain, time of day
- Output: re-ranked route aligned with the user's implicit preferences (e.g., prioritizing CCTV coverage for nocturnal walks).

Results and evaluation

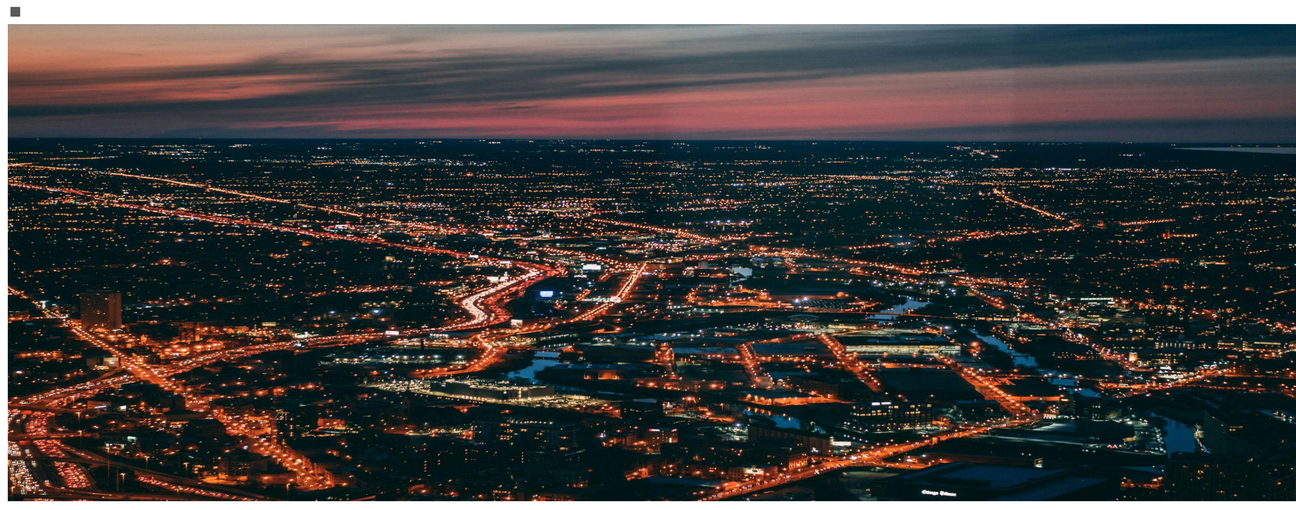
The app was available on the university server, making it possible for each student to test it. As a result, the app proved that its routes are safer than classical ones that don't take into consideration safety measurements.

Whilst the classical apps always aimed for the faster route, thus including dark alleys in their routes, our app avoided the at any cost approach, finding an alternative in more illuminated areas. Also, the classical apps avoid crowded areas, but our app finds those particular paths more favorable for walking at night because a woman can feel that she's not alone.

Moreover, to ensure the strict access of only women to this feature in our app, we have developed a security feature that allows only women to access these routes by using an OCR algorithm for validating their sex using an ID.

Conclusion

UrbanPathfinders contributes to enhancing the safety of women in urban environments by providing intelligently optimized routes that minimize exposure to risk factors, leveraging real-time geospatial data and machine learning technologies. By empowering users with data-driven navigation options, the application addresses both physical mobility and the psychological sense of safety. As part of our future development plans, we aim to expand the application internationally and tailor it to local safety contexts in different cities.



References

[1] H. Gehani, S. Ponnusamy, "Mobile Application-Based Women's Safety and Security System Using AI," In Impact of AI on Advancing Women's Safety, IGI Global, 2024.

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