Work-in-Progress: Real-Time Vehicular Traffic-Based Crowd Density Estimation for Reducing Epidemiological Risks

Somaia Alhazmi[1], Seren Lowy[2], Albert Mo Kim Cheng, *Senior Member, IEEE*[3]
[1]smalhazmi@uh.edu, [2]solowy@uh.edu, [3]cheng@cs.uh.edu

***Abstract*—Many applications have been released for predicting the spread of the COVID-19 pandemic in different areas, which helps many countries control the spread of COVID-19 and other contagious diseases. The RT-CIRAM is a mobile phone-deployable application, which analyzes up-to-date data from multiple open sources with the help of HPC/cloud computing and time-critical scheduling and routing techniques. This app aims to help users practice social distancing and reduce infection risks by advising about crowded areas in their environment. An important layer of data in the operation of this app is the density of people currently occupying different areas a user might travel through. However, this information is not directly available, since it depends on knowing the precise location of persons, for which individuals can choose to deny permission by turning off location services to protect their privacy. Our project implements a new approach to extrapolate from indirect information such as traffic speed on roads to derive the crowd density at each location to be visited. This approach can be useful for reducing infection risks from COVID-19 and other contagious diseases.**

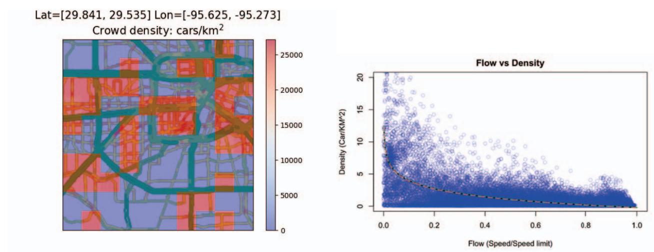
I. Introduction

Numerous models have been developed to predict COVID-19 transmission and the effectiveness of non-pharmaceutical interventions, with ongoing research using evolutionary AI to optimize these strategies. The RT-CIRAM system [1] aims to promote social distancing by recommending optimal locations and times for activities based on user inputs to minimize infection risk. A key challenge is inferring crowd density from indirect information, which our paper addresses by adapting a technique for estimating traffic density using movement speed data. We implement a prototype module that uses real-time traffic speed data and equations from Wirz et al [4] to estimate crowd density. We discuss correlations between them and demonstrate similar behavior in vehicle and pedestrian traffic through SUMO simulations, where increased flow corresponds to decreased density. Our app estimates real-time crowd traffic density over a grid using traffic speed data from TomTom Traffic, which leverages GPS sensors in vehicles and devices [3]. The data includes both current and free-flow traffic speeds, allowing us to compute density using an equation from Wirz et al. When the current speed equals the free-flow speed, density is considered zero. This method is computationally efficient as it uses numerical location data without video processing [4].

$$\rho_{crowd}(v) = \frac{\gamma \cdot \rho_{max}}{\rho_{max} \cdot \ln\left(\frac{-v_0}{v - v_0}\right) + \gamma}, v \neq v_0 \qquad (1)$$

II. IMPLEMENTATION

We have developed a Python app that estimates traffic densities using real-time data from TomTom Traffic® APIs. processes this data to calculate vehicle density, and adjusts for maximum traffic density values. Leveraging the requests-futures library for efficient API access, the app visually represents density data as color overlays on map backgrounds, with transparent squares showing the number of cars per square meter. It accounts for varying speed limits on different road segments to enhance accuracy. The app, available at [2], provides detailed traffic density maps, as illustrated in Figure 1a for Houston, Texas. In our project, we used SUMO and Python to simulate and analyze traffic in Sugar Land (Houston suburb), Texas. We created a detailed simulation network from OpenStreetMap data and used activityGen for realistic traffic generation based on city demographics. During the simulation, we captured real-time traffic data to calculate vehicle density and flow on a grid. Our analysis, using logarithmic linear regressions, found a significant inverse relationship between vehicle flow and density, with the logarithmic regression providing a better fit. The coefficient for log(vehicle-flow) was -1.815644, indicating that higher flow corresponds to lower density, with this relationship being highly significant 1b. In future work, we will analyze correlation between car and pedestrian densities at street intersections and assess the impact of infrastructure on these correlations.



(a) Density plot: Houston, TX (b) Logarithmic Regression

References

[1] Albert M. K. Cheng. "Real-Time COVID-19 Infection Risk Assessment and Mitigation based on Public-Domain Data". In: *2021 IEEE/ACM HPC for Urgent Decision Making (UrgentHPC)*. IEEE. 2021, pp. 29–35.

[2] Somaia Alhazmi and Seren Lowy. *Extrapolating crowd density from traffic speed*. 2023. URL: http://salhazmi.pythonanywhere.com/.

[3] TomTom International BV. 2022. URL: https://developer.tomtom.com.

[4] Martin Wirz et al. "Probing crowd density through smartphones in city-scale mass gatherings". In: *EPJ Data Science* 2.1 (2013), pp. 1–24.

2771-571X/24/$31.00 ©2024 IEEE
DOI 10.1109/EMSOFT60242.2024.00009