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POLICY BRIEF

Pilot of Vehicle Occupancy Detection Technology

Sara J. Hendricks and Philip L. Winters
Center for Urban Transportation Research
University of South Florida

For more information, contact: Sara Hendricks
Email: hendrick@usf.edu

BACKGROUND AND OBJECTIVES

Transportation agencies gather vehicle occupancy data for various purposes including measurement of travel demand such as person throughput on highways. One approach to improving efficiency and reliability of travel is to initiate programs to incentivize filling passenger car empty seats, thereby reducing the number of peak period vehicles on the highway. In the operation of a managed lanes facility, the ability to accurately distinguish between a single-occupant vehicle (SOV) and a high-occupancy vehicle (HOV) would allow facility operators to correctly charge the appropriate toll amount to the user's account, while also rewarding carpoolers with reduced or toll-free access to the facility.

The purpose of this study was to field test an innovative smartphone application (app) developed by RideFlag Technologies, Inc. (herein referred to as RideFlag) and assess its ability to accurately detect faces and determine vehicle occupancy. The following research had two objectives: 1) independently establish the app's accuracy; and 2) test the app's ability to successfully deliver notification of rewards earned to app users who carpool. Researchers did not include back-office integration with a managed lanes authority as part of this study.

METHODOLOGY

The test began on July 20, 2022, and concluded February 28, 2023. A total of 29 carpoolers participated in the study, for a total of 837 logged trips using the app. Participants logged trips on geofenced segments of Interstate 95 (I-95) in South Florida, I-275 in the Tampa Bay region of Florida, and I-15 in the Salt Lake City region of Utah. A geofence is a digital boundary for a real-world geographic area, which is defined by using Global Positioning System (GPS) or radio frequency identification (RFID) technology. This boundary allows software applications, such as RideFlag's tool, to activate a specific action when a mobile device crosses into or out of the defined region. The app detects when a mobile device enters a highway, regardless of whether the app is running in the foreground or background of the phone.

The app uses realness and similarity as two primary metrics to verify a carpool. Realness is an artificial intelligence (AI)-trained model that looks for distinctions between a human face and an artificial/replica of one. Realness is configurable and determined based on what threshold is selected by the managed lanes authority. When the app detects a face and assesses enough information, it will provide a percentage that it checks against the pre-determined threshold and then communicates that knowledge to the carpoolers (i.e., users) in real time. As the app is making determinations, the users will see a gray frame around each of their faces on the phone screen. If the app finds them to be real individuals, then they will receive a green frame. The second metric is similarity.

A similarity score represents the relative match of the faces present during the initial verification and reverification. The app does this by assessing the facial geometry of a given face and temporarily storing that information locally on the user's smartphone. Facial geometry includes measurements between key landmarks of a person's face (e.g., distance from tip of nose to bottom lip). A similarity score's threshold can also be configured to be more or less strict, depending on the needs and goals of the managed lanes agencies and authorities. Carpoolers who registered to take part in the pilot, downloaded the app and logged carpool trips. Each carpool trip required the use of just one mobile device per carpool. Carpoolers were notified through the app when each carpool trip was verified. For the test only, the app was configured to also record digital photos of participants when they verified and reverified their carpool occupancy. This configuration allowed independent evaluators to directly compare realness/facial geometry data and photo evidence of the carpool. This configuration is not necessary for deployment, as the collection of facial geometry data does not require digital photos.

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When a carpooler successfully completed a trip (i.e., they successfully verified occupancy at the beginning of the trip and reverified their carpool occupancy at the end of their trip), the app would display a tally of their total verified carpool trips. Carpoolers received $5.00 Amazon e-gift card value per successful carpool trip, for a maximum of 36 carpool trips.

RESEARCH FINDINGS

Four outcomes of the vehicle occupancy detection (VOD) process were measured with each carpool trip. These included a True Positive (TP) (i.e., occupancy accurately validated when HOV trip occurred), a True Negative (TN) (i.e., occupancy accurately validated when HOV trip did not occur), a False Positive (FP) (i.e., occupancy not accurately validated when HOV trip did not occur) and a False Negative (FN) (i.e., occupancy not accurately validated when HOV trip did occur). From the perspective of the volunteer carpoolers, their logged trips were determined to "pass", meaning their logged carpool trip was verified as a carpool for the purpose of earning the incentive, or "fail", meaning that the trip was not validated as a carpool. Out of a total of 837 total logged carpool trips, there were 648 logged trips that were found to be TP trips. One trip was identified to be FP, and 13 trips were identified to be FN. A total of 121 trips were identified to be TN. For purposes of this evaluation of the Ride Flag app, the category of TN includes not only the cases in which there was just one occupant detected in the vehicle, but also those logged trips in which the rules of app use were not followed or cases in which no trip was taken, as evidenced by the trip timestamp. Due to the unavailability of all data needed for independent verification of some logged trips, there also were a total of 54 trips deemed inconclusive. These 54 trips were set aside. Positive predictive value (PPV) (precision) describes the proportion of positive predictions (TP) that were in fact TPs.

PPV = $TP/(TP + FP)$ = 648/(648 + 1) = 0.9985

Negative predictive value (NPV) describes the proportion of negative predictions (TN) that were in fact TNs.

NPV = $TN/(TN + FN)$ = 121/(121 + 13) = 0.9030

Nine of the FNs were due to an overly strict signature threshold. The agency can lower the threshold.

POLICY AND PRACTICE RECOMMENDATIONS

Researchers recommended that prior to deployment of the app, a test period should be staged to decide the acceptable balance of FNs and FPs (i.e., signature threshold) based upon input from the managed lanes authority, which reflects their program goals. A sponsor of app implementation, such as a toll road authority or commuter assistance program, could choose to strike a different balance between shortening the time required for detection and heightened accuracy, which satisfies the minimum accuracy threshold to achieve the agency's goals. For example, the study team for this pilot elected to reverify every carpool at the end of each carpool trip, to establish false negative rates but other sponsors may prefer to reverify a smaller subset of carpool trips, selected at random, to reduce the burden on the user. The technology RideFlag deployed in this study was the second version tested (i.e., v2). According to RideFlag, preliminary findings from this study were used by the vendor to inform successive versions of the app deployed in other regions.

This pilot did not focus on counting everyone in the vehicle, just whether there was more than one person. For areas that incentivize only carpools of three or more people, more testing would be necessary. Counting more occupants is a configurable option. Given the uncertainty of the app's accuracy before the project began, this pilot did not automate the delivery of rewards ($5 Amazon egift card value per recorded trip, up to 36 trips) through the app. Future research may examine how to automate the process, whether it be gift cards or discounts or other types of incentives, such as reserved carpool parking. Future research may also explore other elements of back-office integration with the app.

Another area of future research is to glean an understanding of the segments of the traveling public who see the benefits of the app. Some aspects of the app may cause hesitancy in adoption among some groups. The USF Carpool Study build included saving photos and a map of where they entered and exited the geofenced corridor in the database. RideFlag designed these features for researchers to verify the accuracy for this USF Carpool Study. Other sponsors may wish to keep those features for the same reasons. This could result in some consumer resistance to use the tool. A social marketing approach could provide insight into what would make the app more attractive than the alternatives or what benefits would outweigh the barriers of using it.

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