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RESEARCH ARTICLE

Mobile Application to Assist Traffic Officers in Managing Congestion

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Abstract: Peak-time traffic congestion on high-level roads has persisted for decades, significantly affecting the environment, drivers' health, and the countries' economy. During peak hours, traffic officers can be seen managing traffic flow in congested areas, making significant contributions to alleviating congestion hotspots. Despite, numerous research findings on traffic congestion, few have addressed the specific role played by traffic officers. Therefore, the study aims to introduce an application to aid traffic officers in alleviating congestion on High–Level Road by proposing appropriate solutions. Initially, a structured questionnaire was distributed physically among 51 police officers stationed at 3 randomly selected locations along High-Level Road. Survey data analysis at a 95% confidence interval, revealed majority of officers identified the morning peak hour period as 6:00 am to 9:00 am, Furthermore, officers expressed a need for manual confirmation and selection of all duty points, push notifications, projected traffic for 15 min intervals, three modes of traffic data presentation (layer, chart, text) and sorting options for traffic details based on the nature of traffic. Following Agile methodologies, a prototype application was meticulously developed for this purpose utilizing daily backup traffic data from Google Maps, and APIs to predict traffic conditions. This study aims to enhance congestion management decision–making by furnishing real-time suggestions to officers.

Keywords: *Application, Congestion, Peak Time, Prototype, Software, Traffic*

Introduction

Traffic congestion is a well-known global problem, and all countries and cities around the world have already faced this problem in different magnitude. In modern or developed countries, the situation seems to be tolerable**.** Traffic congestion poses a significant challenge for low and middle-income countries, and Sri Lanka has grappled with this issue for several decades. According to Nduhura Munga et al. (2015), traffic congestion can be defined as a state of traffic flow when the travel demands exceed the road capacity. The A4 road, commonly referred to as the Colombo-Batticaloa Highway, stands as the longest highway in Sri Lanka. One section of this road, known as the High-Level Road, serves as a vital transport corridor in the country, traversing through key urban centers such as Nugegoda, Maharagama, Kottawa, and Homagama. Typically, traffic congestion is pronounced towards Colombo in the mornings and away from Colombo in the late

afternoons. However, this pattern can be disrupted by accidents, protests, adverse weather conditions, or other incidents leading to roadblocks. Despite the presence of traffic lights at most crossroads, traffic police often manage critical junctions during peak traffic hours. As such, a significant number of traffic officers can be observed along the High-Level Road, and their placement and timing contingent upon traffic conditions and incidents. The Japan International Cooperation Agency (2014) underscores the significance of the A04 access road linking the Colombo Metropolitan area to the Southern Expressway, where urban and long-distance traffic converge. Thathsarani and Lanel (2019) noted a surge in traffic congestion in the Colombo Metropolitan area, while Sandaruwan et al. (2019) advocate for

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carpooling as a means to alleviate congestion. Perera et al. (2021) evaluate manual and video-based automated vehicle counting procedures, while Weerasinghe et al. (2020) examine the impact of traffic congestion on workplace stress. Akhtar and Moridpour (2021) offer a systematic review of real-time traffic congestion prediction using machine learning models, while Noei et al. (2014) propose a geofencing approach for emergency vehicles to navigate congestion caused by traffic lights. Ackaah (2019) explores the feasibility of utilizing advanced traveler information systems (ATIS) to manage traffic congestion in developing countries. Denmark, one of the world's pioneers in Smart City Initiatives, has already begun to use a range of mobile tracking technology. Copenhagen connecting illustrates how this might aid in traffic optimisation and congestion reduction (Sakr et al., 2022).

This study aims to develop a software prototype for traffic control on the High-Level Road. The research scope is limited to, analyzing traffic congestion between two selected points on the High-Level Road during peak periods.

Materials and Methods

To identify areas where traffic is controlled by traffic police officers during peak hours, a close-ended survey was conducted using a pre-tested questionnaire. A total of 51 traffic police officers from three different locations along the High-Level Road were randomly selected as respondents. The survey was completed within three days, covering 17 traffic police officers each day. The survey collected information on peak traffic periods before noon, details of duty points, and methods of delivering suggestions within the mobile application to identify system functionalities.

Data analysis was performed using IBM SPSS 26 and Microsoft Office Excel Professional Plus. Ninety-five percent confidence intervals (CI) were calculated as seen in equation (1)

$$CI = \bar{x} \pm z\frac{s}{\sqrt{n}} \quad \ldots \qquad (1)$$

Where, $\bar{x}$ is the sample mean, z is the confidence level value, s is the standard deviation, and n is the sample size.

If the 95% confidence intervals for the means of the two samples do not overlap, it indicates that the means are significantly different at the $P < 0.05$ level.

Development of mobile application:

The software development project adhered to the Agile methodology. The development process is segmented into phases based on key features; each is developed incrementally until all features are incorporated (Agile process). The development process started with building the suitable Application Program Interface (API) endpoints. NodeJS with the Express framework was utilized to construct the backend of the application. Since the plan involves developing a mobile application (frontend), it is necessary to choose a framework design for an application compatible with both IOS and Android platforms. React Native JavaScript UI software framework is utilized for the development of the mobile application. To adhere to domain requirements, Google Maps, Software Development Kit (SDK), and its API services, particularly distance matrix services for identifying traffic, are integrated with the framework. MongoDB was utilized as the primary data storage solution.

Key steps in generating suggestions include:

1. Identifying manageable reasons for congestion at relevant duty points (by-roads).
2. Assessing traffic congestion along a road stretch
3. Identifying real-time traffic alleviation opportunities
4. Determining the execution duration for each signal command

Results & Discussions

Survey Results

Peak traffic period before noon:

To identify the time when the app is most useful, correctly identifying the morning peak traffic hours is a prerequisite. Based on the analyzed data, the morning peak hour period is identified as 6:00 am to

9:00 am, with the highest percentage of respondents at 50.11% (95%CI 47.78-52.44). According to the Sri Lanka Police (Edirisinghe, 2014), the peak hours of traffic congestion before noon in Sri Lanka are from 6:00 am to 9:30 am. The second highest group of respondents, accounting for 36.49% (95%CI 35.53-37.41), identified the morning peak hours for traffic congestion as 6:30 am to 9:00 am. Therefore, the rest of the traffic officers will be able to access traffic management suggestions for their identified times (Fig. 1).

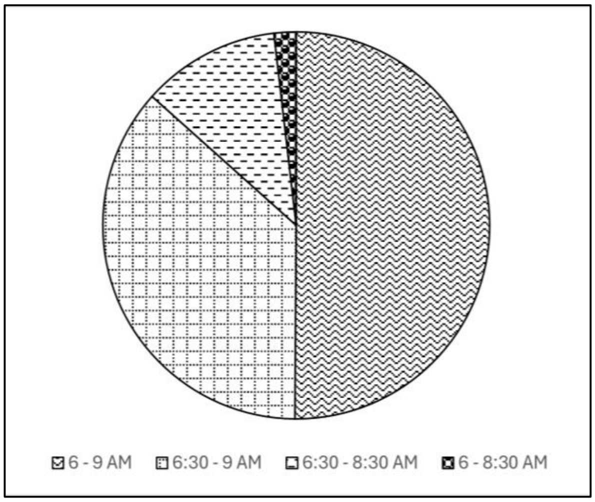

Figure 1: The most accurate period for morning peak traffic schedule.

The need for users to manually verify the duty point:

Traffic police officers have multiple duty points throughout the day, necessitating the development of a method to identify each user's specific duty point. According to the data analysis, 63.5% of respondents (95%CI 62.5-64.5) require a manual confirmation of their duty point. The next highest respondent group, comprising 30.72% (95%CI 29.6-31.8), "may be requiring manual confirmation". Only 5.77% of police officers agree to proceed without confirming their duty point. Additionally, users will ensure that they are retrieving suggestions related to their specific duty points. This feature allows users to change their duty point if the assumed one is incorrect or to stop the process if the selection does not yield the correct results. Reasons for manual verification may include several duty points within a small range and doubts about location accuracy.

Grouping the duty points:

The sample survey reveals that 46.18% of respondents (95%CI 45.5-46.9) prefer the selection of all duty points near their current location, with the nearest one serving as the default selection. The second highest respondent group, comprising 36.49% (95%CI 35.5-37.5 stated that they have no idea about the question. Additionally, 17.33% of police officers expect a selection from all the duty points related to their police station (Fig. 2).

User-preferred type of notification for suggestions:

The question aimed to determine the most appropriate type of notification for rush times. The results of a sample survey indicate that 73.1% of respondents (95%CI, 71.6-74.5) prefer push notifications. Additionally, 13.5% (95%CI, 11.8-15.2) prefer voice notifications. In-app notifications with command illustrations and in-app notifications without command illustrations received 7.6% and 5.8% of the responses respectively. These results demonstrate that push notifications were significantly preferred at 5% probability level.

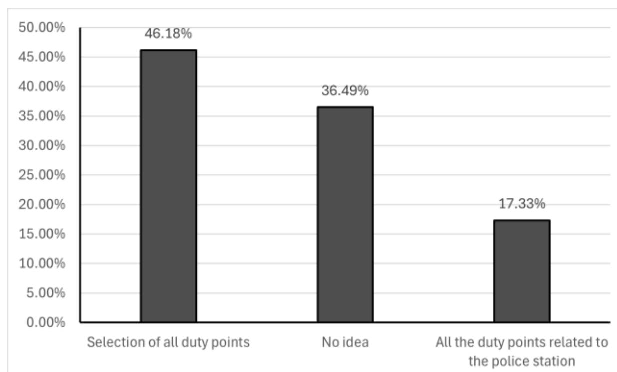

Figure 2. Response to the selection of duty points

Design and Implementation of the application

The screen depicted in Figure 3 is the view of the developed application that allows traffic officers to confirm their current duty point. This option was included in the application based on the survey data analysis. Upon accessing this screen, the application first identifies the user's current location, which is displayed in the text view at the top of the screen. Additionally, the user's current location can be visualized on the map view provided on the same screen. Subsequently, all pre-recognized duty points near the current location are loaded into a dropdown menu.

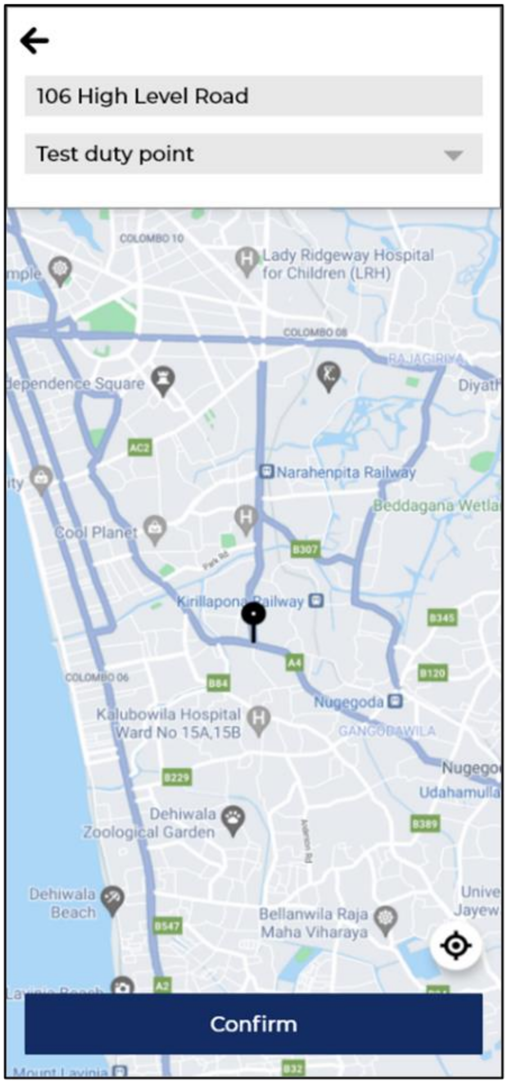

Figure 3: Screen of confirming the duty point.

The default selection in the dropdown menu is the nearest duty point. This feature has been developed and included in the application in accordance with the findings of the analysis (Fig. 2).

After confirming the duty point, the user will be directed to the view depicted in Figure 4. This is the screen where the application searches for suggestions based on real-time traffic data. Once a suggestion is found, the user will receive a notification. Additionally, there is a button labelled “End duty” that allows the user to terminate the process.

Figure 4: Screen of Generating Suggestions

This is the screen where the application searches for suggestions based on real-time traffic data (Fig. 4).

Once a suggestion is found, the user will receive a notification. Additionally, there is a button labelled “End duty” that allows the user to terminate the process.

As depicted in Figure 5, the user receives a notification containing a summary of the suggestion.

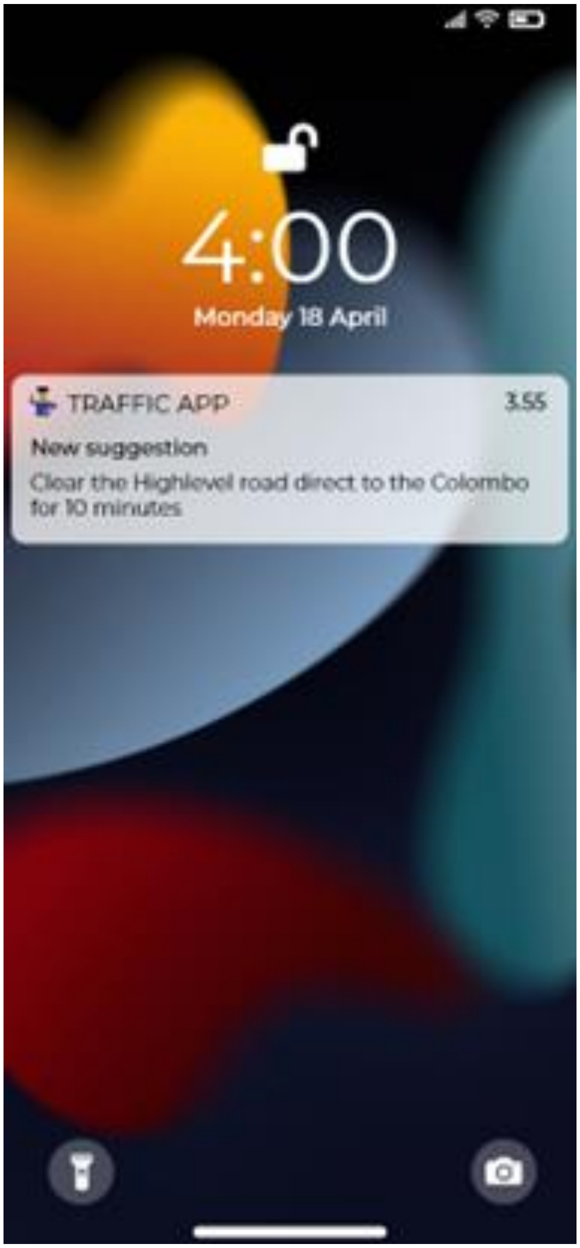

Figure 5: Screen of Push Notification

The decision to include push notifications in this application was based on the analysis conducted. This feature enables traffic officers to receive real-time notifications without needing to keep the application open in the foreground on their mobile devices.

When the user clicks on the push notification received within the suggestion duration, the application opens the suggestion and prompts the user to either proceed with it or skip it, as shown in Figure 6. If the user accepts the suggestion, they will not receive any further suggestions until the current one expires. However, if they choose to skip the suggestion, the application will continue searching for new suggestions. Upon starting the suggestion within the application, the user will be directed to the screen depicted in Figure 7.

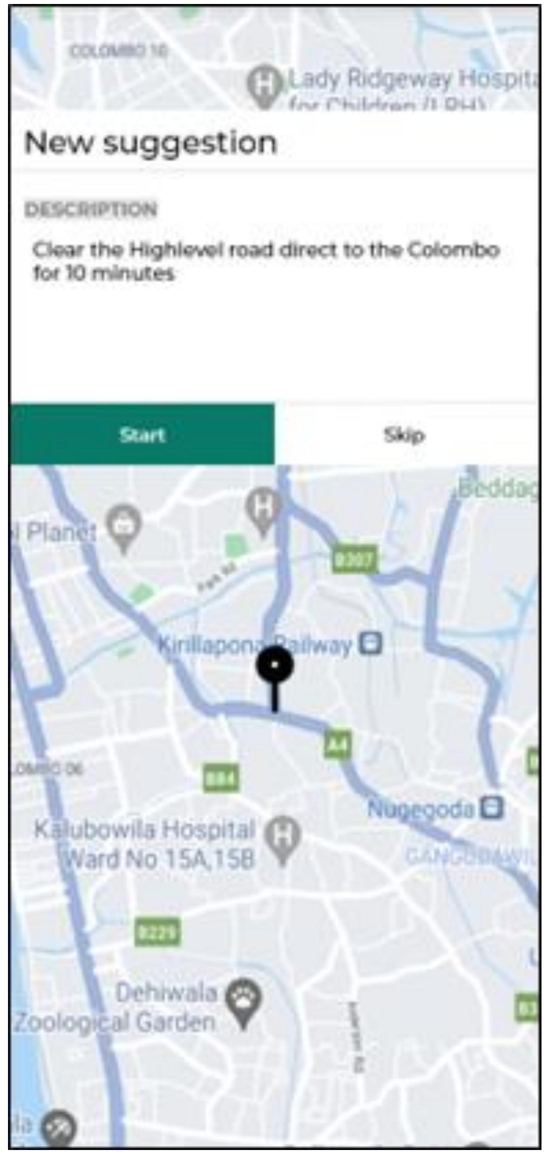

Figure 6: Screen of New Suggestion

Here, a timer displays the remaining time for the current task, and background reminders to notify the user when the task duration is about to end. In recent years, the increased use of smartphones and mobile applications has made it easier to provide real-time information to consumers.

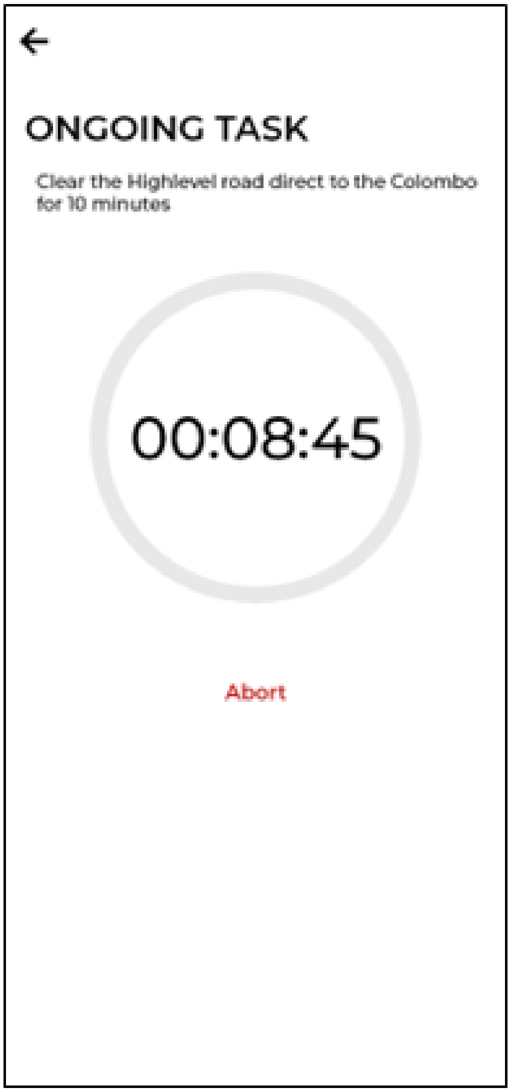

Figure 7: Screen of Ongoing task

Such applications have been used in various fields and improved their efficiency while saving time. (Conroy et al., 2014, Siuhi and Mwakalonge, 2016, Zydney and Warner, 2016, Chris and Gbadamosi, 2017).

Conclusion

The persistent peak-time traffic congestion on the High-Level Road has necessitated the continual deployment of traffic police officers over several decades to manage the influx during rush periods. The principal focus of this study has been to strengthen their decision-making process with the ultimate goal of effectively alleviating congestion. This objective has been pursued by furnishing real-time traffic management suggestions to traffic officers. In order to achieve this, a prototype application was meticulously developed using Agile methodologies. The efficacy of the prototype application was demonstrated through practical application; however, a comprehensive verification of its usability remains outstanding. It is anticipated that the developed application will render the traffic control system more user-friendly and contribute significantly to the reduction of congestion and its attendant adverse effects. To ensure sustainability in the market, continuously improve the app with regular updates, user feedback, and advanced technologies like machine learning. Establish strong partnerships with government and industry, expand geographically with local adaptations, and maintain robust data security to build user trust and engagement. A future direction for this development could involve integrating machine learning algorithms to enhance the effectiveness of management suggestions.

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