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Exploring Pedestrian Noncompliance Crossing in Complex Traffic Environment Using Computer Vision: A Case Study of Kabul City Intersections

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Extended Abstract

Noncompliance crossing is a prevalent behavior among pedestrians at intersections in low-income countries. This phenomenon exposes pedestrians to consecutive conflicts in a complex traffic environment. In Kabul city, pedestrians have severely violated behavior, particularly at major intersections on an urban arterial street, making it a high-risk location for pedestrian safety. According to previous studies [1], [2], and [3], the waiting time at the curbside, traffic volume, walking speed, pedestrian distraction, pedestrian amenities, and nearby land use are factors that influence pedestrian noncompliance behavior. However, the impact of noncompliance behaviors on pedestrian crossing speeds remains unclear in a severe consecutive conflict zone, i.e., the area with continuous pedestrian and vehicle interactions. Pedestrian crossing speed is a critical parameter to determine the efficiency of traffic operations and safety at intersections [4], [5]. Therefore, the study hypothesizes that pedestrian noncompliance behavior is positively correlated with decreased pedestrian crossing speed in conflict zones. To investigate the hypothesis, this study aims to explore how pedestrian noncompliance attributes affect pedestrian crossing speed in conflict zones of a complex traffic environment.

To achieve this aim, 12-hour video data was collected over three days from the Baraki intersection in the city of Kabul. Video footage is analyzed using computer vision techniques to extract pedestrian crossing-related data from interested regions, i.e., under the influence of conflict zones at each crosswalk. Data related to pedestrian crossings were extracted by combining three main computer vision techniques: automatic detection, manual tracking, and inverse perspective mapping. To detect pedestrian noncompliance crossings, the You Only Look Once V8 (YOLOv8) deep learning model, i.e., first introduced by Redmon [6], is trained on annotated images. For tracking purposes, a Python program based on the OpenCV library is used to track pedestrian trajectories. For accuracy, inverse perspective mapping is then applied to convert pedestrian positions in the image plane to their real-world coordinates. The effect is analyzed by taking advantage of comparative statistical analysis, i.e., ANOVA and t-test, between crossing speed of pedestrians with compliance and noncompliance attributes in a microscopic scale.

From the results, 87% of pedestrians were detected to engage in noncompliance crossing behavior. A total of 627 and 93 pedestrian trajectories were extracted for noncompliance and compliance crossing events, respectively. The kernel density estimation is conducted to visualize pedestrian crossing-related data in both perspective and bird's-eye views. In contrast to the study conducted by Shaaban et al. [7], the result of the heatmaps shows that pedestrians take a longer path when crossing illegally, dictating the change in the pedestrian crossing pattern due to the occurrence of consecutive conflicts. Therefore, pedestrians are more willing to create frequent routes at corners and outside of crosswalks. The result of statistical analysis demonstrates that pedestrians have significantly lower crossing speeds (mean difference 0.07 m/s; $t_{(2663.8)} = 6.407$; p-value<0.05) when they do not obey traffic rules and cross the intersection with consecutive conflict. Furthermore, the result

of ANOVA reveals that both pedestrian attributes (compliance and noncompliance crossing) and the condition of the crosswalks significantly affect pedestrian crossing speed.

In conclusion, the study sheds light on pedestrian attributes in a complex traffic environment of a low-income city. The findings show that pedestrians have a lower crossing speed and a longer path when crossing intersections under the influence conflict of vehicles. The results also showed that pedestrians create several prohibited routes in the vicinity and corner of the crosswalk, indicating the complexity of traffic in the interactions studied. Furthermore, the study has limitations that need to be addressed. First, only one site is investigated. Second, factors such as built environments, age, gender, and other not considered. It recommended that this study be further expanded, and future work should consider these limitations.

Keywords: Pedestrian, Noncompliance Crossing, Computer Vision, Pedestrian Safety, and Conflict Zone.

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