International Co-operation on Theories and Concepts in Traffic Safety

Enhancing Road Infrastructure Safety through Innovative Methodologies for Traffic Sign Visibility Assessment

[1,2] *Ziyad N. Aldoski, [2]Csaba Koren.

[1]email: ziyad.nayef@dpu.edu.krd Department of Highway and Bridge, Technical College of Engineering, Duhok Polytechnic University, 61 Zakho Road, 1006 Mazi Qr Duhok, Kurdistan-Iraq.

[2]Faculty of Architecture, Civil Engineering and Transportation Sciences, Department of Transport Infrastructure, Széchenyi István University, 9026 Egyetem tér 1, Győr, Hungary.

Introduction

The advancement of autonomous mobility represents a critical frontier in pursuing safer and more efficient transportation systems. An important field of this advancement is the evaluation of road infrastructure safety, particularly regarding the visibility of traffic signs. This is crucial in ensuring the seamless integration of autonomous vehicles (AVs) into our roadways. While traffic signs serve as primary navigational aids for human drivers, characterized by their distinctive shapes and bright colors to capture attention, even at high speeds, enabling AVs to recognize and understand these signs accurately presents a significant challenge. This obstacle underscores the complexity of achieving a comprehensive vision assessment, highlighted by the diverse nature of road environments and the varying capabilities of emerging technologies. The necessity of addressing this issue is becoming increasingly clear, with the standardization of traffic signs within and across national borders gaining increasing importance alongside the emergence of AVs.

The **objective** of this paper is to compare the results obtained using LiDAR techniques, handheld retroreflectometer assessment, and human evaluation. It aims to explore their efficacy in assessing traffic sign visibility. It examines their effectiveness in evaluating traffic sign visibility, aiming to provide valuable insights for developing adapted vision assessment techniques suited to the specific demands of AVs. Human evaluation offers subjective perspectives rooted in human perception, while retroreflectometry delivers quantitative reflectivity measurements. In contrast, LiDAR intensity metrics furnish precise data concerning the light intensity reflected from traffic signs. Moreover, by integrating these methodologies with on-site human assessment and surrounding area intensity measurements, we seek to enhance the accuracy of traffic sign visibility assessment. This integrated approach not only evaluates sign visibility but also considers the surrounding environment, significantly influencing vision perception for both human drivers and machine vision systems in AVs.

Methodology

This study's methodological framework includes three integrated primary sides to assess traffic sign visibility comprehensively.

- RetroSign GRX 554 retroreflectometer was used to measure the retroreflection coefficient (R_A) of 160 traffic signs according to EN 12899-1 standards. Measurements were conducted at pre-set illumination and observation angles, capturing additional data such as sample color, temperature, humidity, and GPS coordinates.

- For on-site human evaluation, a survey with three questions for each traffic sign was formulated, accompanied by safety instructions and a map. Each sign was assigned a numerical identifier and marked on its pole, and volunteers were provided with safety vests. Surveys were conducted individually; participants had to assess visibility, readability, and contrast to surroundings. A total of 42 volunteers participated in this evaluation process.
- Data acquisition was performed using two AVs with four LiDAR sensors and two GPS receivers mounted on their roofs. The stereo cameras on these vehicles recorded a video log, augmenting the LiDAR sensors' data from various orientations to ensure comprehensive coverage and improved object identification. LiDAR intensity data for 175 traffic signs and 70 surrounding areas were extracted from the point cloud data using Python scripts and supplementary software packages, including Foxglove Studio and CloudCompare Open3D source.

A comparison analysis was conducted between all obtained data, assessing the performance of each method in evaluating traffic sign visibility. Statistical methods implemented through SPSS were employed for evaluation, examining the relationship between the results obtained from the three methodologies. This comprehensive approach aimed to clarify the strengths and limitations of each method and explore potential correlations or differences in their findings, contributing to a deeper understanding of traffic sign visibility assessment in AV environments.

Results

A comparative analysis of results shows that an integrated approach comprehensively evaluates traffic sign retroreflectivity. Handheld retroreflectometers provide objective measurements, while human evaluations offer subjective assessments, and LiDAR intensity measures the reflected light from signs. The study highlights significant differences between subjective and objective assessments. The weak correlation between LiDAR intensity and R_A suggests that factors like surface condition and manufacturing quality influence the results. The relationship between R_A and human perception is complex, requiring consideration of factors such as contrast, color, ambient lighting, sign placement, clarity, and environmental context. This multifaceted approach is essential for accurate traffic sign assessment and design.

Discussion and conclusion

In conclusion, significant differences were found between the three assessment methods (handheld meter, LiDAR sensors, and human evaluation). This study highlights the importance of using various objective and subjective assessment methods to evaluate traffic sign visibility thoroughly. Each method has its strengths and limitations, necessitating a comprehensive approach. Retroreflectometers provide precise measurements of R_A but do not fully capture human perception, which is influenced by sign placement, environmental conditions, and individual visual acuity. LiDAR technology offers detailed spatial and intensity data but shows limited correlation with retroreflectivity measurements and human evaluations. Therefore, combining standardized retroreflectivity measurements, LiDAR data, and human assessment is crucial for accurately assessing traffic sign visibility and effectiveness. This integrated approach facilitates informed decision-making, enhances traffic sign design and implementation, and improves road safety, especially in AVs, ensuring safer and more efficient road networks.

Keywords: *Road safety; autonomous mobility; traffic sign visibility; LiDAR intensity; retroreflectivity; human evaluation.*