

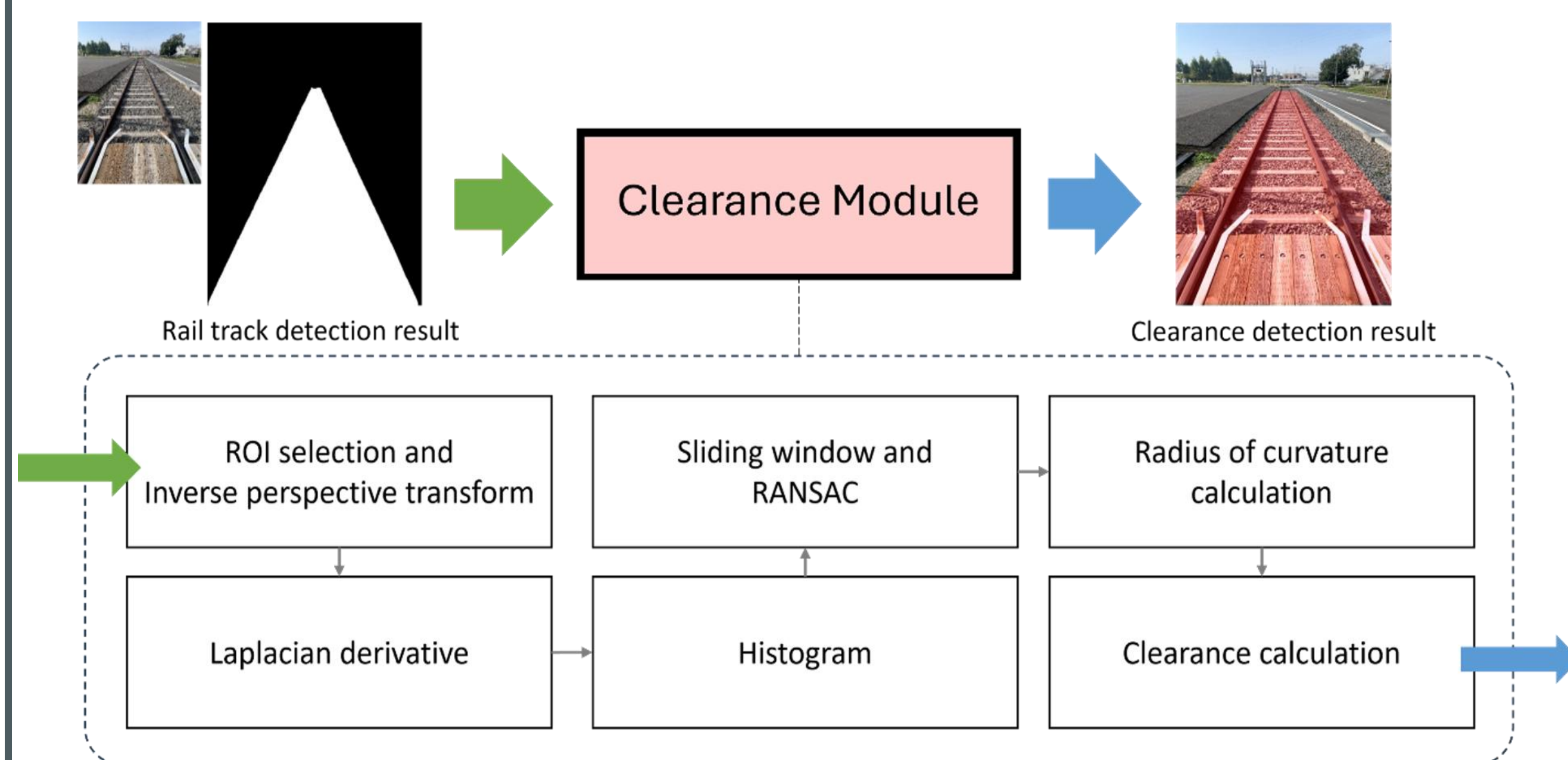
Tram Vehicle Clearance Identification Algorithm for Driverless Tram Operations

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Introduction

To realize driverless tram services in our societies, it is undeniably crucial to equip trams with the capability to understand their surrounding environment, especially the front area, to prevent accidents and achieve the highest level of operational safety. Therefore, the main purpose of this study is to introduce an algorithm that identifies tram vehicle clearance, defined as the distance from the rail track center to both ends of the tram vehicle. This clearance identification helps determine whether any obstacles are present within the tram's path.

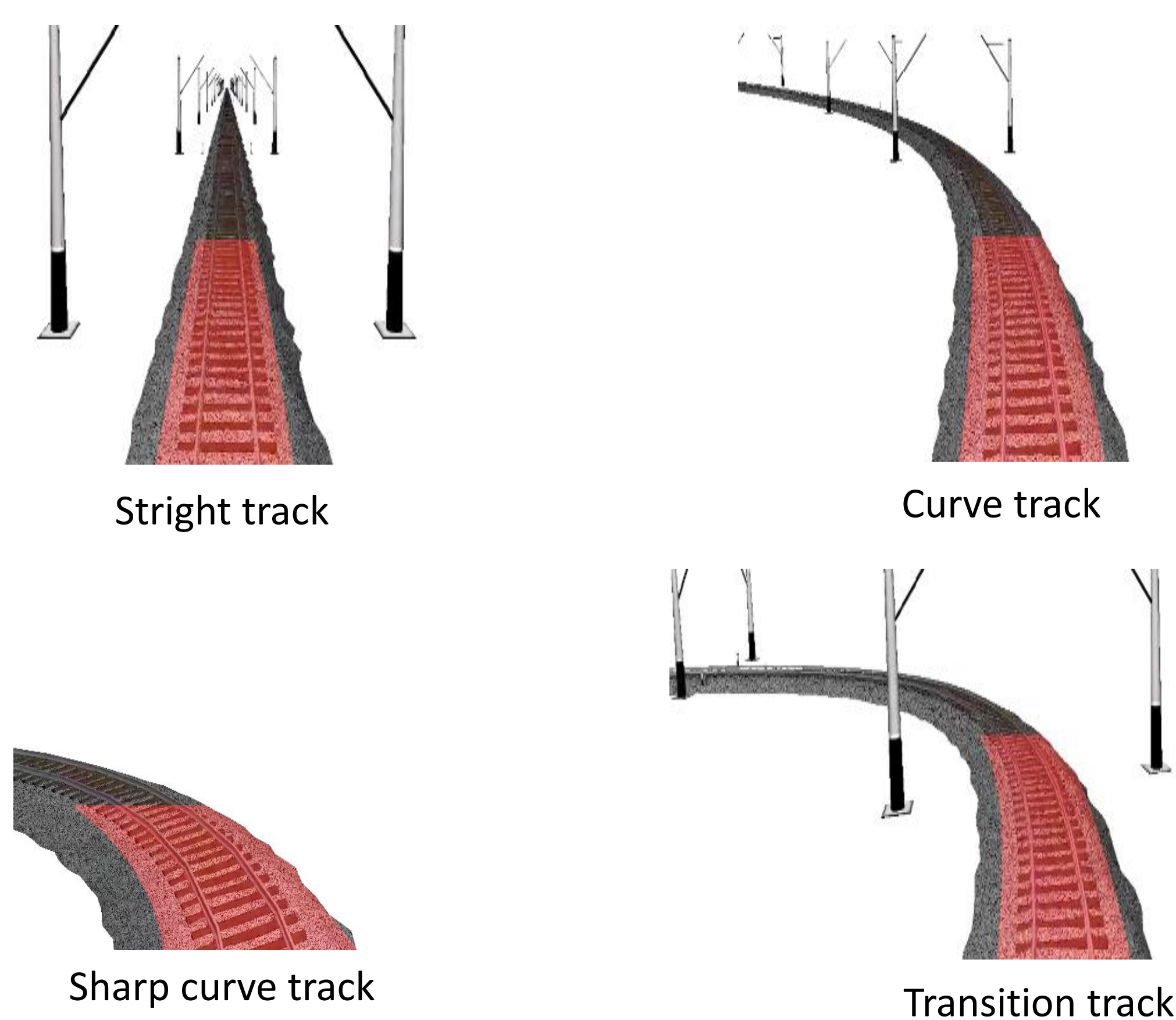
Proposed Algorithm



The proposed clearance algorithm is designed based on various conventional image processing techniques working in sequence. It receives rail detection mask and then detect tram clearance.

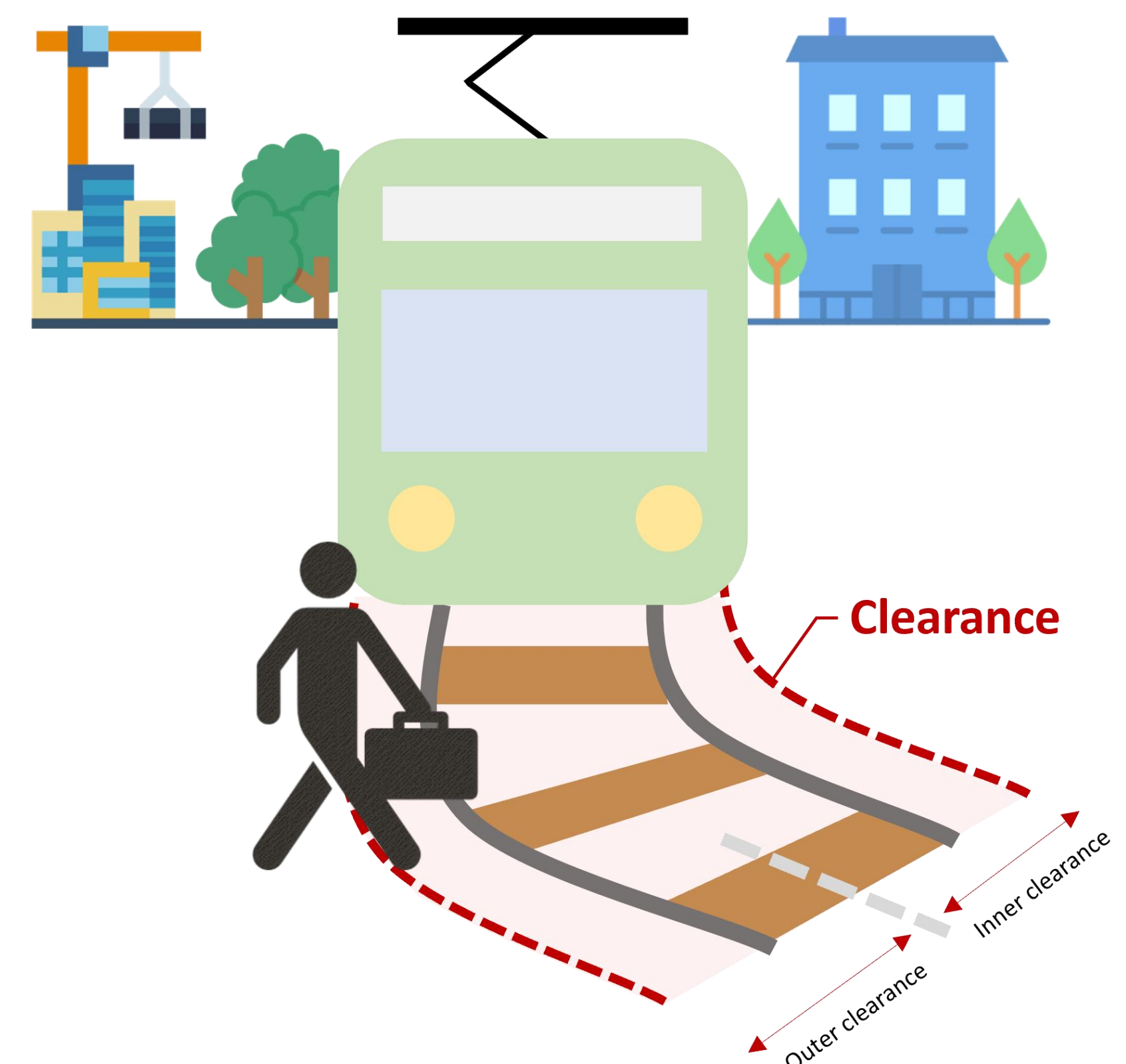
Evaluation Method and Results

The algorithm's performance is validated through simulation-based evaluations. To ensure its reliability across various rail track layouts, the evaluation covers four types of track sections: straight, curved, sharply curved, and transition segments. The accuracy of the algorithm is assessed using the Intersection over Union (IoU) metric.



Publications

S. Hovanotayan, K. Nakano, 2024, Tram Driving Path Identification Systems for Driverless Tram Operations, Proceedings of the 6th International Conference on Railway Technology: Research, Development and Maintenance (Railways 2024), 1-5 September, Prague, Republic of Czech.
S. Hovanotayan, K. Nakano, T. Takata, H. Nagasawa, 2024, Algorithm for Detecting Vehicle Clearance for Driverless Tram Operation, The 22nd ITS Symposium, 13-14 December, Kumamoto, Japan.



Clearance

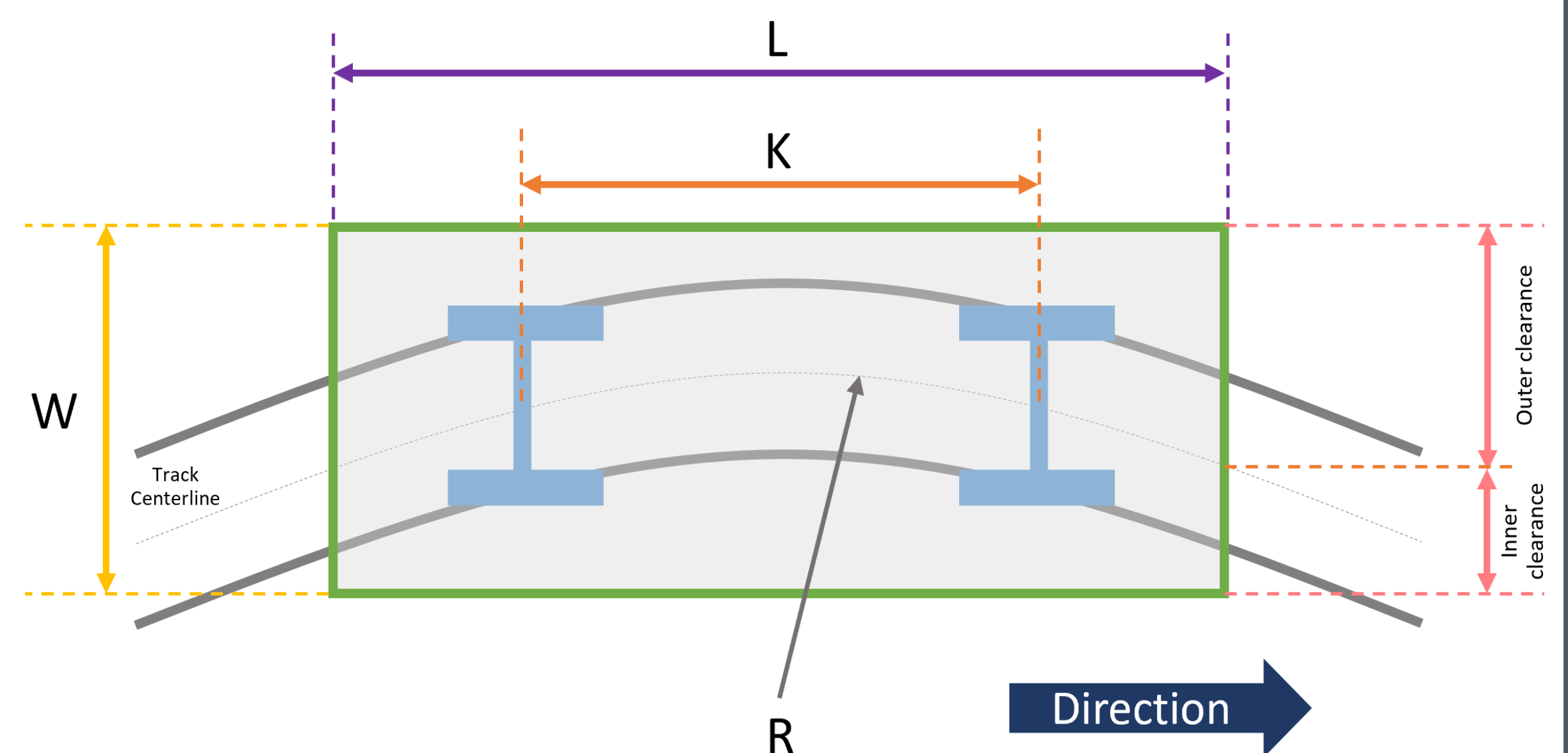
For tram vehicle clearance, it can be obtained through the following equations

$$\text{Outer Clearance} = \frac{W}{2} + \frac{L^2 - K^2}{8R}$$

$$\text{Inner Clearance} = \frac{W}{2} - \frac{L^2 - K^2}{8R}$$

Note:

W = vehicle's width; L = vehicle's length
 K = bogie-to-bogie distance
 R = radius curvature of track centerline



Track layouts	Number of frames	Mean IoU*
Straight track	1000	0.9995
Curve track	1000	0.9792
Sharp curve track	1000	0.9564
Transition track	1520	0.9457

*IoU = Intersection-over-Union

Conclusion

The results demonstrate that the algorithm achieved a mean IoU above 0.9 in all cases, indicating high accuracy in identifying tram clearance. In the future, we are planning to further validate this algorithm with real-running data.