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SIMULATION MODELLING OF AGV TRANSPONDER PLACEMENT

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ABSTRACT

In recent years, automated guided vehicles (AGV) have been widely utilized in automated container terminals for material transfer. AGV can navigate in a facility via communicating with transponders buried beneath the surface of the ground. However, little research has been done on the placement configurations of the transponders which have significance in facility layout, bringing in flexibility and not hindering productivity. In this scope, this study provides a simulation model to evaluate the effectiveness of different transponder placement configurations and helps company decide the best transponder layout.

1 INTRODUCTION

The vision of port operators is to have a fully automated port container terminal and maximize operational productivity. The yard automation has led to usage of automated guided vehicles (AGVs). Transponders buried underground can be used to communicate with AGVs and provide navigation. The conventional way of planting transponders has been restricting the movements of AGVs to a certain way, for instance fixed lanes in a planned layout, which makes later alteration of lanes difficult. Therefore, in this study, transponders are placed in a free-range landscape, allowing AGVs to adopt different paths as per need. Extensive studies have been performed to optimize AGV routing such as Online Preference Learning (Choe et al. 2016). However, no methodology has been developed to determine the configurations of the placement of transponders. This could result in a surplus of transponders that may not be used in the navigation of the AGVs and introducing additional costs. In view of this gap, this study provides a simulation model to simulate AGV movements in a yard whereby transponders are placed in free-range. By comparing simulation results, a better transponder placement configuration can be obtained.

2 METHODOLOGY

Mathematical Formulation of Steering Dynamics: To simulate turning of AGV, steering dynamics of AGV need to be formulated. AGV needs to fulfill Ackerman condition in order to perform a safe turn without tyre slipping. When performing a turn, Ackerman steering geometry requires vehicle outer wheel and inner follow curved paths with a common turning point and different radii. When turning angles of wheels are known, the turning point and turning radii are known, and the AGV movement can be described.

Exploring Possible Configurations: The configurations follow the rule of uniformness, i.e. layout pattern has a uniform distance and uniform continuous pattern of the layout. Triangle, square and hexagon are studied specifically. Density is a measurement of the number of transponders placed in a given area.

Simulation Platform: Due to the complexity of the problem itself and high demand of flexibility, it is difficult to use commercial software to develop the simulation model. Hence, an open-source discrete event simulation framework – O^{2}DES.Net, which has been proven to be very flexible for complex industry projects (Zhou et al. 2018), is used in this study. The demo of the platform is illustrated in Figure 1.

3 EXPERIMENT AND CONCLUSION

In the study, changeable parameters are layout configuration and density, front and rear wheel steering angle. By tuning these parameters, three results are generated, i.e. the average inter-transponder distance (AITD), the maximum inter-transponder distance (MITD) and the percentage of time the AGV experiences more than one transponder in the reader (duplicates %D). The AITD and MITD give a good understanding on what is the distance an AGV travels without being "seen" by operator. Larger AITD/MITD value indicates operator has lesser control over the AGV. When passing more than one transponder at a time, the reader on the AGV will report error; hence, ideally duplicates (%D) should be zero.

For each layout pattern and density, wheel turning angles are tuned and the three values (AITD, MITD, %D) are obtained. An example of the result can be found in Figure 2. The objective is to find a layout pattern to minimize number of transponders. The company usually specifies the maximum allowable inter-transponder distance and %D. A pattern with the smallest density satisfying these two requirements can be found and minimum number of transponders can be achieved.

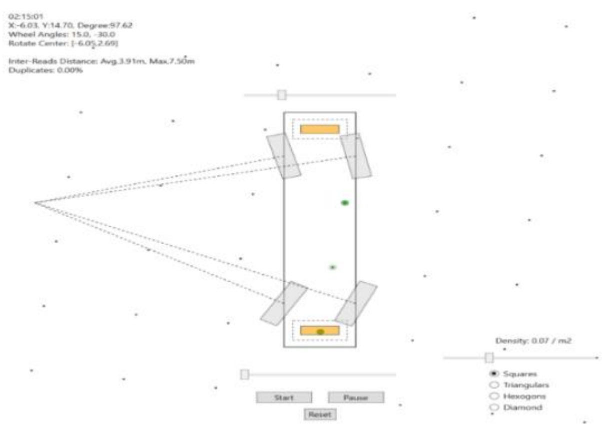

Figure 1: Simulation Toolbox.

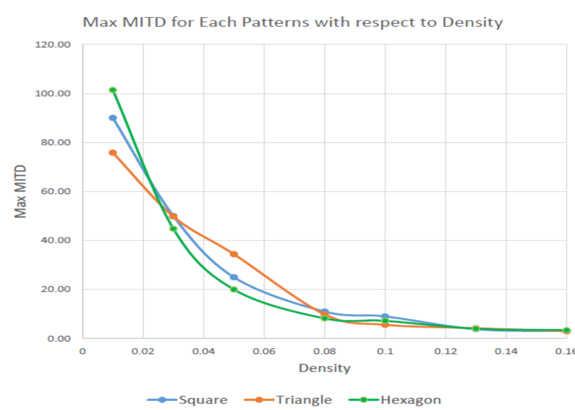

Figure 2: Simulation Result.

This study provides a promising simulation tool to evaluate different transponder placement configurations. By specifying the maximum inter-transponder distance and %D, an optimal pattern with the lowest density can be obtained. In the simulation, the starting point of AGV in each iteration is fixed. However, randomness of the starting point will affect the resultant performance of the layout configuration. Randomization of AGV starting point can be included in future studies when evaluating the robustness of the layout pattern.

ACKNOWLEDGEMENT

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REFERENCES

Choe, R., J. Kim, and K. R. Ryu. 2016. "Online Preference Learning for Adaptive Dispatching of AGVs in an Automated Container Terminal". *Applied Soft Computing,* 38: 647-660.

Zhou, C., H. Li, B.K. Lee, and Z. Qiu. 2018. "A Simulation-based Vessel-truck Coordination Strategy for Lighterage Terminals". *Transportation Research Part C: Emerging Technologies*, 95: 149-164.