A Fuel Cost-less Bus Driver Allocation through Bus IoT Data Analysis

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1. Introduction

Bus companies are currently facing many management issues, such as a decrease in the number of passengers and dealing with the rising bus fuel cost[1]. In particular, bus fuel cost is the second largest expenditure in the bus business and has been increasing recently, therefore, the studies on reducing bus fuel cost have been attracting attention. In this paper, we try to analyze a bus operator's driving characterization through bus IoT data and propose a fuel cost-less driver allocation scheme based on the analysis. It is so difficult to directly investigate the fuel cost of each driver, therefore, we use values of running resistance calculation whose characteristics have a deep relation to the fuel cost in a previous study [2]. With values of the running resistance of each driver, we aim to allocate a driver to a suitable route for improving fuel cost on a bus company.

2. Proposal scheme

We express running resistance per second by following,

$$1000 * W * (1 + \sigma) \times \alpha \tag{1}$$

where W, σ, and α are the weight of a bus, the mass equivalent coefficient of the rotating parts, and acceleration per second, respectively [2]. W and σ are constant values so that the running resistance depends only on α. The acceleration per second α is calculated for each driver when they drive a certain route. To discover the detail of drive characteristics for each driver, we classify 3 categories of the α: straight, left curve, and right curve, which are defined as α_s, α_l, and α_r, respectively. To realize a suitable driver allocation, we must consider route characteristics, which detail the ratio of straight, right curve, and left curve. Here, we define the running resistance of driver $i \in I$ operating route $j \in J$ as following,

$$\alpha_{i,s} \cdot S_j + \alpha_{i,l} \cdot L_j + \alpha_{i,r} \cdot R_j \tag{2}$$

where S_j, L_j, and R_j indicate the ratio of straight, left curve, and right curve in route j. Additionally, $\alpha_{i,*}$ indicates accelerations for each direction of driver i. Using these parameters, we minimize the following equation,

$$F = min \sum_{i \in I} \sum_{j \in J} \left(\alpha_{i,s} \cdot S_j + \alpha_{i,l} \cdot L_j + \alpha_{i,r} \cdot R_j \right) \tag{3}$$

where F is the minimum total running resistance in all routes when all drivers are allocated to the routes. F will become 0 in the case of all $\alpha_{*,*}$, however, all buses must be operated on time in real situations, which is a limiting constrain.

3. Evaluation

For calculating running resistance, bus IoT data such as the acceleration data for drivers and bus route data is required so we obtained it from real bus company through MQTT protocol. The range of data is from August 1 - 31 in 2021, which contained data of 55 drivers and 6 routes. First, we calculated accelerations for 3 directions in each driver on a certain route with the obtained data. Second, we investigated the ratio of straight, left curve, and right curve in each route. For example, each ratio of a certain route is 89.507 %, 5.342%, and 5.151%. The characteristic of the bus company's route is that the ratio for straight takes a higher ratio on almost all routes. Based on this characteristic, we allocate drivers with low running resistance on straight roads to a long straight route. As a result, the total running resistance in 6 routes could be reduced by 7% with our allocation scheme.

4. Conclusion

In this paper, we propose a cost-less driver allocation scheme to improve fuel costs for a bus company. As a result of the simulation, our proposed scheme reduced 7% running resistance compared with the current real allocation.

References

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