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Research on Composite Layout Method Based on Multi-Traffic Detector on Road Section

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Abstract: In terms of the layout and application of traffic detectors, the existing fixed detector layout methods mainly focus on the layout of a single type of traffic detectors. The layout of detectors is determined by analyzing the relationship between the effect of data acquisition under different layout schemes of detectors and the spacing of detectors.

Keywords: Composite Layout Method, Multi-Traffic Detector on Road Section.

1. Preface

Considering that the early detectors are embedded detectors, such as induction coil detectors, which need to dig the road surface and cut off traffic flow, this section chooses non-embedded detectors as supplementary detectors. As mentioned above, the selection of detector needs to consider such factors as acquisition parameters, data accuracy, cost, data transmission, installation and maintenance of detector, road environment and road condition.

2. Combination Layout of Multiple Detectors on Traffic Detector Section

Figure 1 compares the sum of the average absolute relative errors of the travel time corresponding to different detectors with different accuracy under different number of detectors, i.e. the objective function values in the model. The X-axis represents the total number of detectors, including the number of coil detectors and the number of microwave detectors. The Y-axis represents the average absolute relative error of travel time. The "5% coil and 5% microwave" in the legend indicates that the speed detection accuracy of coil detectors is 95% and that of microwave detectors is 95%. The percentage in the legend indicates the detection error of the detector. Similarly, the other two values in the legend also indicate the detection error of the detector. It can be clearly seen from the figure that the sum of MARE decreases with the increase of the number of detectors. When the number of detectors is 21, only coil detectors

are installed. At this time, the error values of the three schemes are the same and are at the highest value; with the addition of microwave detectors, the error values decrease accordingly. When the number of detectors reaches 105, the decline rate of error becomes slower. Under the same number of detectors, different accuracy of microwave detectors will lead to different degrees of error (three different color blocks). The higher the accuracy of microwave detectors (the blue bar in the figure) the lower the error value. For detectors with low detection accuracy, increasing the number of detectors can achieve the same accuracy as the data collected by high-precision detectors. For example, the height of blue rectangular strips with 42 detectors is basically the same as that of green rectangular strips with 84 detectors and red rectangular strips with 273 detectors. The smaller the error of the detector, the less the amount of data needed. Since the precision scheme of the detector studied in this section is "5% coil and 10% microwave", the layout of the detector under this condition will be emphasized in the following section. Compared with the green bar in the graph, when the number of detectors exceeds 189, the improvement of data accuracy is not obvious, so 189 is chosen as the maximum number of detectors.

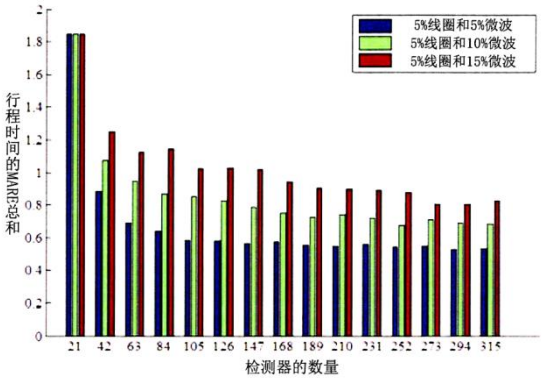

Figure 1 Comparison of Detector Layout Schemes under Different Detection Accuracy

Fig. 2 draws the layout of nine detector combination schemes. The data at the top of the figure represents the total number of detectors. The corresponding line is the highway section. The black short solid line on the left side of the line represents the layout of the coil detector, while the red short solid line on the right side represents the layout of the microwave detector. As can be seen from the figure, with the increase of microwave detectors, the distribution of detectors tends to be uniform, but at the same time there will be over-concentration, which will lead to redundancy of detectors, resulting in a waste of funds and manpower. Combining with Figure 1, we know that the centralized placement of detectors also results in that the detection accuracy of data does not increase with the number of detectors. From Figure 2, we can also see that when the number of detectors is 126, the layout of detectors is relatively uniform and the coverage rate is high. When the number of detectors increases to 147, 168

and 189, the coverage of detectors does not change much compared with 126, but the redundancy of detectors increases a lot. Therefore, it can be inferred that the number of detectors has an optimal value. Increasing the number of detectors will not increase the estimation accuracy, but reducing the number of detectors will affect the estimation accuracy.

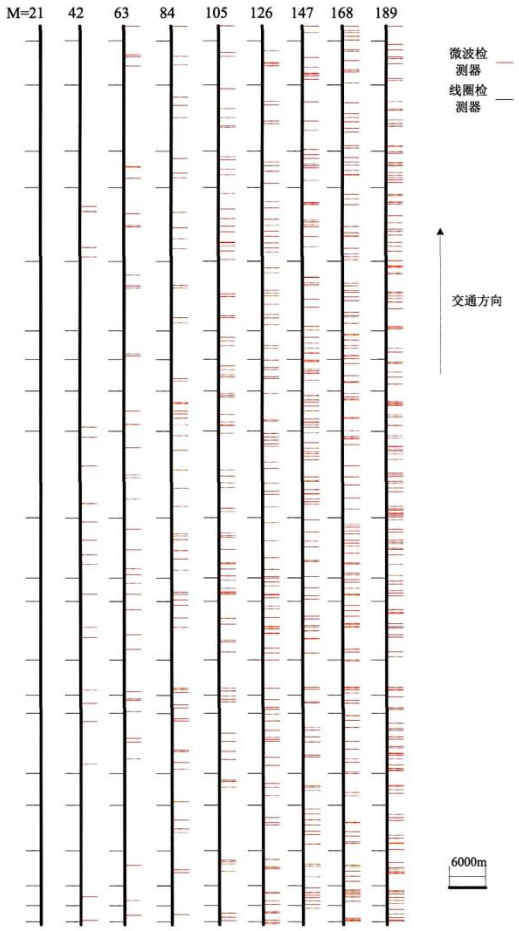

Figure 2 Layout of Detectors

Figure 3 shows the average absolute relative error of travel time under different layout schemes. The X-axis represents the sequence coding of the road segment, and the Y-axis represents the average absolute relative error of the travel time. As shown in the figure, when only coil detectors are laid on the road, the average absolute relative error of travel time is the largest, followed by the scheme with the same number of microwave detectors. When the number of detectors exceeds 84, the improvement of estimation accuracy is not significant. Considering the limitation of cost and quantity, the optimal scheme of detector placement is to use the least detectors to obtain higher detection accuracy. Therefore, after the above analysis, the optimal number of detectors to meet the requirements of this section is 84. At this time, the average distance between detectors is 1.745 kilometers, the maximum distance is 5.6 kilometers and the minimum distance is 0.2 kilometers. In addition, by comparing the

average absolute relative errors of travel time between 21 and 42 detectors in the figure, the estimation accuracy of data can be improved by increasing the number of detectors and optimizing their positions (about 41.9%). Similarly, when 21 microwave detectors are added, the detection accuracy increases by 11.6%. This shows that our method is effective in laying out multi-type detectors. It can also be inferred that optimizing the locations of detectors can improve the accuracy of data more effectively than increasing the number of detectors.

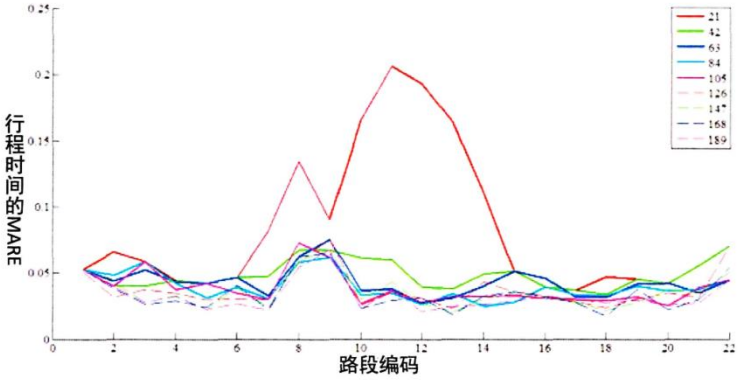

Figure 3 Average absolute relative error MARE of travel time under different layout schemes

3. Conclusion

The work of the detector is affected by road traffic flow, road physical structure, climate conditions and other factors. According to the characteristics and working principle of the detector, it can be seen that different detectors are affected by the above factors. Therefore, the above factors should be taken into account when considering the combined application of detectors. Based on this, the layout principle of multi-detector combination is formulated.

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