

## CUMCM-2024 Problem E

### Traffic Flow Control

With the acceleration of urbanization, the rapid popularization of motor vehicles, and the expanding range of human activities, urban traffic congestion has become increasingly severe. Even in non-central cities, traffic congestion has become a "pain spot" affecting local economic development and public happiness, and has turned into a challenging problem for local government.

Consider a small town with a famous scenic spot. There are local residents' travel and transit vehicles around the scenic area, as well as a large number of tourist vehicles. Tourist vehicles often weave at low speed on the surrounding roads as they search for parking, thereby reducing traffic efficiency.

Figure 1 shows the layout of two main roads in the town: Weizhong Road, which from Huanxi Road to Huandong Road, is about 3.5 km; and Jingzhong Road, from Huanbei Road to Huanan Road, is about 1.8 km. Along these two main roads, there are 12 intersections, and the monitoring equipments can record the traffic information in four directions at each intersection. For example, at the intersection of Jingzhong Road and Weizhong Road, there are four directions of traffic flow: north-south, south-north, east-west, and west-east. The traffic information includes the location of the capture, the direction of traffic flow, the time of capture, and the license plate number.

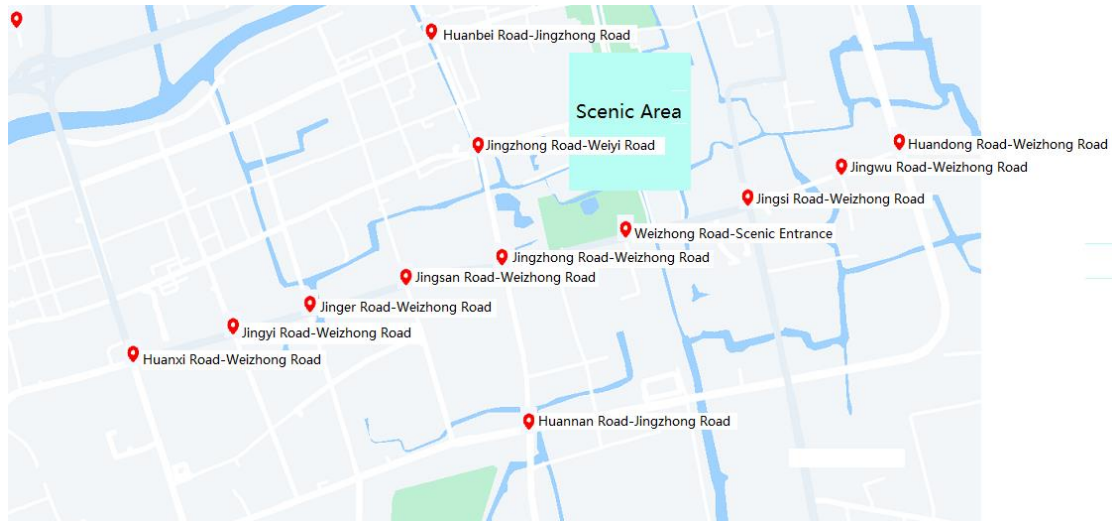


Figure 1 Schematic map of the main roads in the town

Annex1 gives the direction numbers and the distance between different intersections; Annex2 records all vehicle information that occurred on the two main roads with monitoring equipments from April 1st to May 6th, 2024. The monitoring equipments are installed behind the stop line, so it does not know whether the vehicle will turn left, straight or turn right after passing through the stop line.

Due to the presence of residential areas, hotels, and office buildings along the way, vehicles may enter or exit from the parking of these buildings, which may cause sudden appearance or disappearance of vehicles on these two main roads.

Please establish mathematical models to solve the following problems:

**Problem 1** At the intersection of Jingzhong Road and Weizhong Road, a day can be divided into several time periods based on the difference of traffic flow. Please estimate the traffic flow of each phase (including straight and turning in four directions) during these periods.

**Problem 2** Based on the given data and the above model, please optimize the signal lights at all intersections on Jingzhong Road and Weizhong Road to maximize the average speed of traffic on both main roads while ensuring vehicle passage.

**Problem 3** Analyze the data during May Day Golden Week, please estimate the number of parking spaces that need to be temporarily requisitioned by the scenic areas to meet the increased demand.

**Problem 4** During May Day Golden Week, the town implemented temporary traffic controls and managements surrounding the scenic area. For detailed information, please refer to Annex3.pdf. Please evaluate the effectiveness of these temporary controls and managements.

Annex1 Direction numbers and distance between intersections

Annex2 Information of recorded vehicles

Annex3 Traffic controls and management detail during May Day Golden Week