Studying pedestrian flows to improve the Rostov-on-Don’s intelligent transport system

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Abstract. The study included survey of signal-controlled pedestrian crossings throughout the whole city of Rostov-on-Don, a geoinformation model was built, field surveys of pedestrian traffic intensity at signal-controlled pedestrian crossings were conducted in order to identify zones of highest concentration of pedestrian flows, as well as to develop the city’s Intelligent Transport System (ITS) and mitigate conflict situations at the city’s crossings.

1 Introduction

Safety of pedestrians is one of major challenges which has to be addressed when managing road traffic inside large cities and possibly included in the measures aimed to improve the city’s ITS. ITS developments makes it possible to:
- improve the efficiency of managing the road and transport complex in order to meet today’s quality criteria for the transport services and road traffic safety, and to ensure the required level of mobility of the population;
- apply up-to-date information and communication technologies throughout all lifecycle stages of transport infrastructure facilities - planning, designing, construction, operation.

2 Methods

The ITS concept is a concept of intelligent urban mobility of the future where people and the transport system are in close cooperation enabled via innovative modern information technologies [1-3].

Monitoring pedestrian flows is necessary to identify and classify road incidents, for future planning of road works, and for making efficient decisions on pedestrian flow management. These measures can be implemented if a subsystem for monitoring pedestrian flow parameters is established[4-6]. The key objectives of this subsystem are:
- acquisition of pedestrian flow parameters;
- processing the acquired data;
- making a forecast on the pedestrian flow parameters based on the input data;
- data storing;
- communicating the data to other subsystems of the ITS.

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The survey plan included those sections of street and road network in Rostov-on-Don where the ITS is planned for implementation. Following the survey of signal-controlled pedestrian crossings, 132 objects were identified (see Fig. 1). The intensity of pedestrian flows was measured during the morning and evening rush hours.

![Fig. 1. Map of studied survey zones with signal-controlled pedestrian crossings in Rostov-on-Don.](image)

### 3 Results and Discussion

An analysis of the survey results revealed that the highest intensity of pedestrian flows was 2,928 persons per hour at the most congested crossing. It was decided to introduce a four-level scale to evaluate the pedestrian flows intensity. Of these levels, 2% was high intensity (2,250 - 3,000 persons per hour), 7% was above average intensity (1,501 - 2,250 persons per hour), 17% was mid-level intensity (751 - 1,500 persons per hour) and 74% was relatively low intensity (0 - 750 persons per hour) (Figure 2).

For further studies, 20 signal-controlled pedestrian crossings were selected with the highest pedestrian flows intensity, and based on those selected zones, the distribution of pedestrian traffic intensity at the signal-controlled pedestrian crossings was presented (Fig. 3).
Following the results of this analysis, 5 zones were identified where 20 sensor installation points will be located (Table 1).
<table>
<thead>
<tr>
<th>Signal-controlled pedestrian crossing</th>
<th>Number of directions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rostov-on-Don, Bolshaya Sadovaya street - Semashko lane</td>
<td>4</td>
</tr>
<tr>
<td>Rostov-on-Don, Budyonovsky avenue - Sotsialisticheskaya street</td>
<td>4</td>
</tr>
<tr>
<td>Rostov-on-Don, Bolshaya Sadovaya street - Gazetny lane</td>
<td>4</td>
</tr>
<tr>
<td>Rostov-on-Don, Voroshilovsky avenue - Stanislavskogo street</td>
<td>4</td>
</tr>
<tr>
<td>Rostov-on-Don, Voroshilovsky avenue - Varfolomeeva street</td>
<td>4</td>
</tr>
</tbody>
</table>

The ITS development will make it possible to arrange real-time management of transport and pedestrian flows [7-8].

In Figure 4 you can see the road crossing of the Budyonovsky avenue with the Sotsialisticheskaya street. At this crossing the transport flows can turn left and right during the same signal phase with the pedestrian flows, which leads to conflict situations.

![Fig. 4. Road crossing between the Budyonovsky avenue with the Sotsialisticheskaya street.](image)

Road traffic-related human safety means ensuring protection for the transport complex users, including pedestrians and road traffic participants with increased vulnerability. In order to enhance the pedestrian traffic safety, it is proposed to have a separate signal phase for pedestrians, such as diagonal arrangement of road crossing for pedestrians (Bechtel, 2004). Figure 5 shows a diagonal pedestrian crossing [9-12].
Fig. 5. Arranging a diagonal pedestrian crossing.

Crossing the road with the traffic flow fully stopped is, for sure, much safer [13-16].

It is used for marking the road crossings where the diagonal crossing is allowed. Road sign 5.19.3d is used to mark a diagonal road crossing, and with this sign installed, it is prohibited to use signs 5.19.1 and 5.19.2.

To enhance the traffic safety at the intersection of pedestrian and traffic flows, or - even better - between the cars making a turn and pedestrians, it is a very useful practice to use diagonal pedestrian road crossings. However, we should not focus only on the violations of traffic regulations by drivers. It is necessary to provide conditions for pedestrians not to infringe the traffic regulations and be guided by traffic light signals. The traffic signal software should be programmed to mitigate conflicts between the transport and pedestrian flows [17-19].

Figure 6, figure 7 shows the simulation of the current and proposed situations made with the help of AIMSUN software suite. Table 2 shows the scenario efficiency parameters following a simulation.

Fig. 6. Simulation of the current scenario.
According to the simulation analysis, the delay for pedestrians will increase by 21.19 seconds, and the delay for motor vehicles will be reduced by 14.57 seconds. The situation will improve for motor vehicles because there will be no points of conflict with pedestrian flows. The situation for pedestrians will become worse because they will have to wait longer for the pedestrian phase to cross the street. Despite the increased delay of pedestrian phase, the proposed variant of road traffic management will significantly improve the traffic safety in this intersection zone [20-22].

**Conclusion**

1. The study helped identify survey zones with signal-controlled pedestrian crossings in Rostov-on-Don.
2. A geoinformation model was built which is a map of the surveyed zone with signal-controlled pedestrian crossings inside Rostov-on-Don.
3. Throughout the whole Rostov-on-Don a number of field surveys were conducted to study the intensity of pedestrian traffic at the signal-controlled pedestrian crossings.
4. The distribution of highest intensity of pedestrian traffic was presented for 20 signal-controlled pedestrian crossings, a graph was made demonstrating the distribution of the highest intensity of pedestrian traffic at signal-controlled pedestrian crossings.
5. Based on the distribution of the highest intensity of pedestrian traffic at signal-controlled pedestrian crossings, 5 zones were identified where 20 sensor installation points will be located.
6. It was proposed to arrange a diagonal pedestrian crossing.

**References**


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