

Using Data of Control Public Points for Obtaining Values of Speeds on Ribs of the Roads

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Abstract. A new developed scheme of public transport of the Belgorod agglomeration was introduced into the GIS system. This system allows to create a complete graph of roads with directions of public transport, as well as various information necessary to compile a full database. The data of dispatching points of public transport for obtaining velocity values on the edges of the graph of the roads of the city roads was surveyed.

1 Introduction

In connection with the development of a new scheme of public transport in Belgorod, there was a need for an accurate description of the road graph according to which the movement of public transport is already being carried out, and its movement is expected. Based on data from OpenStreetMap [1], traffic signs and road markings, traffic management projects and general plans, NextGIS QGIS [2] formed a single graph of the roads of the Belgorod agglomeration, which has the following form (fig. 1).

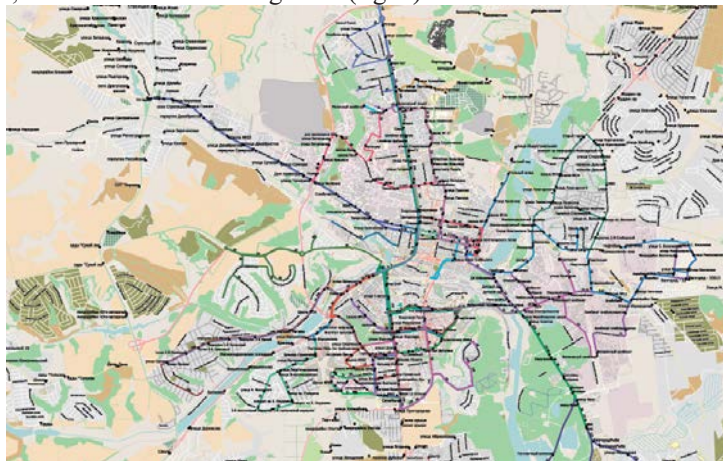


Fig. 1. New scheme of public transport of Belgorod agglomeration.

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2 Theory

The requirements for the graph are presented in the form of the following table [3].

Table 1. The main layers needed to build a road graph.

Layer name	Kind of graphic primitive	Appointment layer
"Territories of human settlements"	Area (polygon)	The layer contains actual names and subordinates of settlements - for the current year. Must contain the main settlements, through which passes and which adjoin one of its borders to the road graph.
"Borders of administrative entities"	Area (polygon)	The boundary layer of administrative entities describes the position of the borders and correlates with the territories of populated areas as belonging to administrative entities.
"Road constructions"	Point, line, polygon	The road structure layer contains all objects of road structures through which the road graph passes, and describes the actual position and dimensions of road structures.
«Road graph»	Components of the edges and nodes - a point, a polyline	The graph of the road network contains topological links of the edges and nodes (vertices), which are the main types of objects of the road graph.

The received data from the GPS / GLONASS trackers to the dispatching system, in the case of the Belgorod agglomeration in the software of the firm "SHTRIKH", are graphically displayed as follows (fig. 2) [4].

Each of the tracks includes certain data, such as date, time, latitude and longitude, altitude, speed, number of satellites used, etc (fig. 3) [5].

As a result of data processing, the summary information is presented as a txt file for each of the routes.

Statistical processing and analysis of data recorded by the tracker on the parameters of the movement of vehicles allow us to evaluate a number of parameters necessary to optimize the timetable for the movement of public transport [6]. In particular, the following parameters can be used:

- time spent for boarding / disembarking passengers;
- the time required to overcome the entire length of the route;
- Interval of public transport for each route;
- speed of vehicles on road sections between control points (main intersections, stops, etc.).



Fig. 2. Graphic display of the track of the public transport dispatching system of the firm "SHTRIKH".

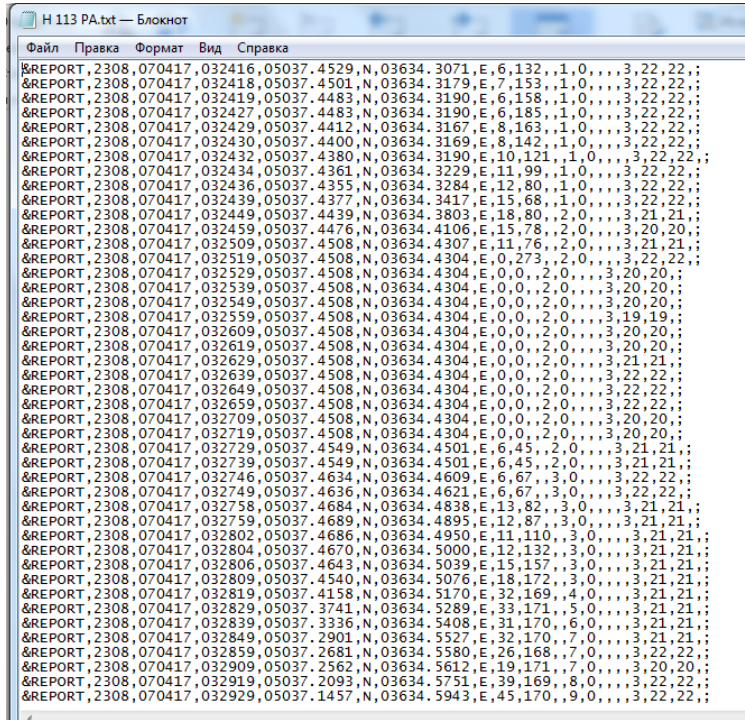


Fig. 3. Data received with GPS / GLONASS trackers.

Statistical processing of the generated parameters allows to determine their dependence on the time of day, day of the week and season [4,7].

3 Results and Discussion

1. The basis for evaluating all of the above parameters is the fixation of vehicle travel times for control points.

The moment of overcoming the control point is determined by the simultaneous fulfillment of two criteria: the achievement by the distance between the vehicle and the reference point of the minimum and the correspondence of the heading angle to the value set for this control point:

$$\left\{ \begin{array}{l} \frac{dR(t)}{dt} = 0; \\ \frac{d^2R(t)}{dt^2} > 0; \\ |Course(t) - Course_CP| < 10^\circ \end{array} \right. , \quad (1)$$

$$R(t) = \sqrt{(X(t) - X_{KT})^2 + (Y(t) - Y_{KT})^2};$$

$X(t), Y(t)$ – current vehicle coordinates in the local coordinate system;

X_{KT}, Y_{KT} – Planned coordinates of the control point in the local coordinate system;

$Course(t)$ – current vehicle angle of the vehicle;

$Course_CP$ – calculated vehicle angle of the vehicle at the control point.

An example of the behavior of the analyzed parameters is given in figures 4 and 5 [8,9].

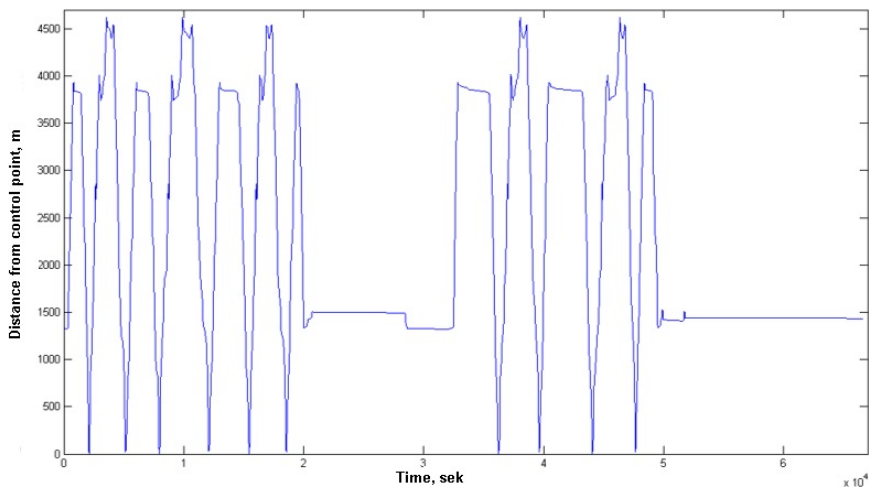


Fig. 4. The distance between the vehicle moving along the route and the control point, as a function of time.

From figures 4 and 5, it is clear that the availability of data on the heading angle makes it possible to identify which of the minima of the function of the distance to the reference point corresponds to a given direction of motion. The result of determining the time of passage of the control point is given in Table. 2. The table shows:

- checkpoint travel time;
- realized course angle;
- Evaluation of the speed of the vehicle at the moment of passage of the control point

[10].

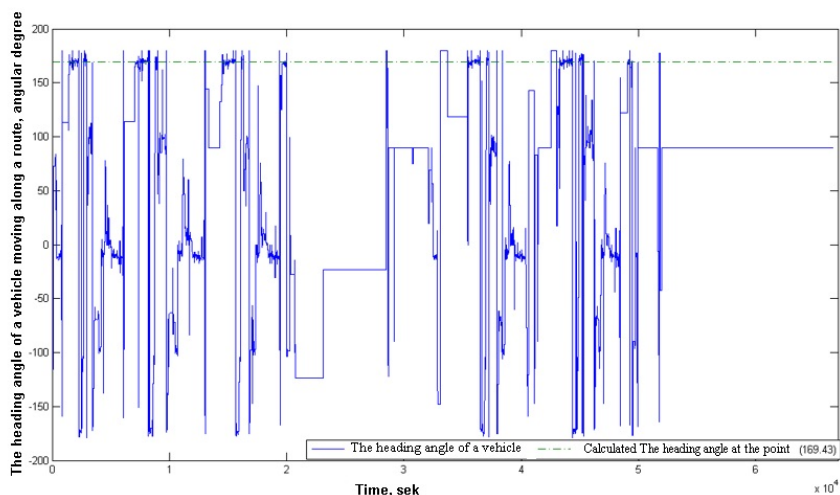


Fig. 5. Moving along a route, as a function of time.

2. To ensure efficient processing of information, it is necessary to fulfill two basic requirements, which must be provided by the software of on-board equipment, in this case software of the firm "SHTRIKH", namely:

- Ensure data acquisition with discreteness no more than 1 sec;
- the fullness of all the provided fields of the information message of the tracker.

Table 2. Checkpoint travel time and traffic characteristics.

Time from the beginning of the movement along the route, sec	Course angle, ang. degree	Speed, m/s
2118	165,851443857380	0,965128100084491
13846	170,867113429434	1,33760429525804
28772	168,609388867566	2,26955223493185
70336	170,510136761690	1,27046240338995
85960	167,615743115747	1,38385763260838

Table. 2 an example of real data shows that the discreteness of the registered data frames varies and reaches a maximum of 21 seconds. On the other parts of the track variations of the discreteness of the times from one second to several tens of seconds were observed, and in some cases of hours, which is most likely due to the turn off of the tracker and does not fall under the category of data skipping.

With such large passes in the data logging for estimating the characteristics of the traffic along the route, it is most rational to select control points on the sections of uniform motion, that is, in conditions when interpolation will not have a significant effect on the result [11].

3. During the movement along the route the vehicle repeatedly passes in the immediate vicinity of the control point, which allows estimating the time spent on the route and its dependence on external conditions, primarily related to the time of the day, the days of the week, etc.

If one of the stops or any other waypoint is selected as a control point, the time between two consecutive passes of this checkpoint may include the time of a long parking of the vehicle at the final point of the route. In this case, a real estimate of the duration of the route is estimated as the difference in the time interval between two consecutive passes of the control point and the parking time of the vehicle at the final point:

$$T_{n,k}(\tau_i) = t_{n,k,i} - t_{n,k,i-1} - \Delta t_{n,i}, \tag{2}$$

$t_{n,k,i}, t_{n,k,i-1}$ – the times of two consecutive passages of the control point, chosen by condition

$$\frac{t_{n,i} + t_{n,i-1}}{2} \in [\tau_i - d\tau, \tau_i + d\tau], \tag{3}$$

τ_i – the average time of the averaging interval to which the parameter is estimated;

n – vehicle identifier on the route;

$d\tau$ – half-width of the data averaging interval;

$\Delta t_{n,i}$ – the parking time at the final point of the route in the interval $[t_{n,i-1}, t_{n,i}]$.

The average duration of a route along a route in a given time interval is determined by averaging the data for all vehicles along the route:

$$T(\tau_i) = \frac{1}{N} \cdot \sum_{n=1}^N T_n(\tau_i), \tag{4}$$

$\Delta t_{n,i}$ is defined as the difference between the times of the end and start points within a given interval for which the criterion:

$$\begin{cases} R(t) < \frac{D_{\text{кп}}}{2} \\ V(t) = 0 \end{cases}. \tag{5}$$

Distance to the central point of the final point of the route:

$$R(t) = \sqrt{(X(t) - X_{\text{кп}})^2 + (Y(t) - Y_{\text{кп}})^2}, \tag{6}$$

$D_{КП}$ – the maximum size of the site of the final point;
 $V(t)$ – vehicle speed.

4 Conclusion

When developing a new scheme of public transport, one of the main indicators is the formation of data on the turnover time on the flight and the time of arrival at each of the stops. To solve the task, data is generated about each stopping point on the route, indicating the boundaries of the stopping point in the coordinates [8].

This approach allows you to form any route from already finished areas, to reveal the minimum and maximum speed, i.e. get all the initial data for the formation of the register and the system of forecasting the arrival at each of the stops of public transport (fig. 6).

	A	B	C	D	E	F
1	Название остановки	Широта	Долгота			
2	Аэропорт	50.645704	36.568044			
3	Аэропорт (граничная)	50.645864	36.568006			
4	Аэропорт (граничная)	50.645176	36.568245			
5	ТРЦ "РИО"	50.642185	36.569208			
6	ТРЦ "РИО" (граничная)	50.642374	36.569198			
7	ТРЦ "РИО" (граничная)	50.641818	36.569391			
8	Автовокзал	50.637325	36.570812			
9	Автовокзал (граничная)	50.637590	36.570769			
10	Автовокзал (граничная)	50.636899	36.570981			
11	МегаГринн	50.632600	36.572355			
12	МегаГринн (граничная)	50.632779	36.572333			
13	МегаГринн (граничная)	50.632274	36.572504			
14	Сокол	50.627529	36.574021			
15	Сокол (граничная)	50.627904	36.573954			
16	Сокол (граничная)	50.627119	36.574173			
17	Швейная фабрика	50.623901	36.575063			
18	Швейная фабрика (граничная)	50.624086	36.575050			
19	Швейная фабрика (граничная)	50.623283	36.575281			
20	БелГу	50.619799	36.576254			
21	БелГу (граничная)	50.620169	36.576155			
22	БелГу (граничная)	50.619452	36.576403			
23	Улица Гагарина	50.616614	36.577167			
24	Улица Гагарина (граничная)	50.617001	36.577105			
25	Улица Гагарина (граничная)	50.616255	36.577324			
26	Улица Мичурина	50.612662	36.578307			
27	Улица Мичурина (граничная)	50.612920	36.578254			
28	Улица Мичурина (граничная)	50.612204	36.578464			
29	Улица Мичурина	50.612310	36.578410			

Fig. 6. Data on the location of stops on the route and their boundaries.

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