Determination of conditions for reliability of travel parameters estimation in a network using "floating" cars

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Abstract. Based on the analysis of the experimental data the article reveals that if in the area under study a travel length is more than 7 km (about 20 minutes of movement), it becomes possible to obtain stable relationships between the specific parameters of traffic in the network. A further increase in the duration of observations does not cause a change in the trip parameters and the value of the correlation ratio for the model. The corresponding results are achieved with a constant cruising of five "floating" cars in the area under study. Moreover, it is proved that reliable results of estimating the traffic parameters on the network are obtained both for fixed traffic routes of "floating" cars and for randomly choosing routes.

1. Introduction

Evaluating the change in the specific travel time it is possible to apply a different method of estimating the reliability of data of "floating" cars than when estimating the share of simultaneously stopped cars in the network. Since the existence of stable dependencies between travel time parameters in two-component models of the kinetic theory of the transport flow has been theoretically and experimentally proven, it is necessary to determine the conditions for obtaining such dependencies according to the study time and the number of vehicles in the network.

Therefore, based on the results of experimental studies in the Rostov-on-Don road network, the main dependences of two-component models of the kinetic theory [1-7] were constructed and their statistical significance was determined for a variety of combinations of the number of "floating" cars and the time of study. Summary data for changing the mileage of cars in a given area are presented in Table. 1.

Table 1. Research data on the parameters of two-component models

Travel length, km	Specific travel time, min / km	Mean-square distance of specific travel time	Specific stopping time, min/km	Mean-square distance of specific stopping time	Specific travel time in free conditions, min / km	Correlation ratio for the model
1	3.108	1.275	0.766	0.654	1.747	-
2	2.875	1,339	0.672	0.581	1.758	0.271
3	2.874	1.142	0.818	0.659	1.474	0.313
4	2.915	1.067	0.832	0.662	1.453	0.419
5	2.949	1.085	0.798	0.622	1.520	0.393
6	3.042	1.149	0.844	0.662	1.522	0.538
7	3.018	1.188	0.822	0.624	1.569	0.384
8	3.051	1.444	0.890	0.948	1.478	0.781
9	3.041	1.407	0.908	0.929	1.445	0.781

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10	3.048	1.391	0.891	0.904	1.476	0.753
11	3.053	1.479	0.896	0.896	1.505	0.747
12	3.084	1.448	0.911	0.880	1.499	0.743
13	3.117	1.468	0.952	0.906	1.469	0.764
14	3.174	1.477	0.979	0.943	1.462	0.776
15	3.191	1.458	0.971	0.928	1.479	0.771
16	3.191	1.438	0.962	0.921	1.481	0.776
17	3.188	1.401	0.979	0.914	1.457	0.770

The same list of parameters, but for a different number of cars is given in Table. 2.

The analysis of the data of Table 1 shows that with a travel length in the study area more than 7 km (about 20 minutes of traffic), it becomes possible to obtain stable relationships between the specific parameters of traffic in the network. A further increase in the duration of observations does not cause a change in the trip parameters and the value of the correlation ratio for the model. Corresponding results are achieved with constant cruising of five "floating" cars (Table 2).

Experimental studies of the estimation of traffic conditions on a controlled road network based on the parameters of two-component models were carried out in two ways: the movement of "floating" cars along fixed routes; the movement of "floating" cars along random routes following any front car.

Table 2. Parameters of the two-component models for different number of cars

Number of cars	Specific travel time, min / km	Mean-square distance of specific travel time	Specific stopping time, min/km	Mean-square distance of specific stopping time	Specific travel time in free conditions, min / km	Correlation ratio for the model
1	3.445	1.568	0.676	0.374	2.243	0.218
2	3.177	1.248	0.673	0.372	1.949	0.241
3	3.319	1.463	0.796	0.610	1.875	0.397
4	3.267	1.410	0.928	0.672	1.674	0.118
5	3.316	1.604	1.030	1.007	1.525	0.745
6	3.230	1.571	0.997	0.996	1.520	0.702
7	3.193	1.494	0.967	0.959	1.512	0.707
8	3.170	1.440	0.992	0.933	1.464	0.693
9	3.174	1.452	0.989	0.906	1.478	0.691
10	3.183	1.418	0.983	0.876	1.493	0.655

Estimating traffic conditions on fixed routes, they were designed in such a way that "floating" cars are constantly on the most congested sections of the downtown of Rostov-on-Don. Due to this, two basic principles for obtaining reliable data are achieved: the main network nodes are controlled, the distribution of "floating" cars is saved when all sections in the studied area are covered.

However, in practice this means that to obtain information about road conditions it is necessary to have "floating" cars that perform only these functions. Using the variant of the experimental research for the movement of "floating" cars on random routes can be interpreted in such a way that data on traffic conditions in intelligent transport systems will be obtained from any vehicle equipped with mobile devices. Such a concept of information support is being developed in the projects "Telematics Pro" in Berlin, "City-FCD" (data of floating cars in the city) in Frankfurt and others. But to use this variant it is necessary to prove that all sections of the network are constantly under control and there are no situations when all "floating" cars congest in one place.

2 Results

For the analysis of these situations, comparative experimental studies were carried out with the movement of cars on fixed and random routes in the same section of the Rostov-on-Don road network. Equal number of cars was used in both variants of research. The most interesting information is the estimation of the location of a set of "floating" cars during the whole experiment.

The analysis of random "floating" cars pathways in the network shows that this way of obtaining the data on traffic conditions ensures the existence of cars throughout the whole area under the study. The situations when all cars are concentrated only in a limited area are excluded. At the same time, there is a certain fixation of cars to some streets due to the intensity of traffic and the dislocation of cargo and passenger objects. If weight factors are taken into account for the distribution of the transport load on all sections of the network, the patterns of changing the location of the "floating" cars correspond to the concentration of the transport load on the sections of the network (Figure 1).

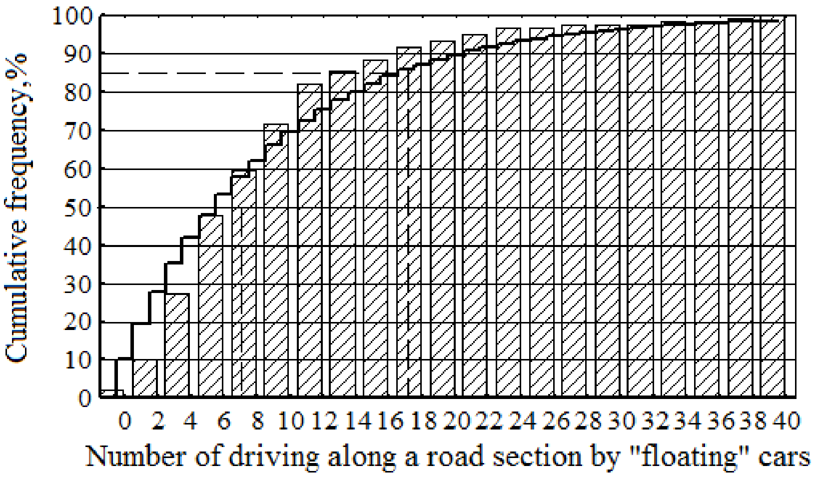

Figure 1. The probability of the travel frequency on the network sections by "floating" cars with random selection of routes

However, in addition to the estimation of the adequacy of the spatial distribution of random "floating" cars, it is necessary to determine the correspondence between data on traffic conditions obtained by a random pattern of traffic and movement along fixed routes. One of the samples of such comparative research data is given in Table. 3.

Table 3. Comparative data for variants of the route choice by "floating" cars

Category of route	The ratio of the specific time of stopping to the specific travel time for 10-minute periods						
	10	20	30	40	50	60	70
Fixed	0.276	0.193	0.513	0.181	0.336	0.103	0.267
	0.156	0.25	0.387	0.156	0.324	0.412	0.281
	0.452	0.228	0.436	0.388	0.272	0.258	0.339
	0.323	0.446	0.276	0.069	0.191	0.252	0.260
	0.208	0.296	0.235	0.291	0.179	0.532	0.290
	0.431	0.332	0.127	0.333	0.212	0.321	0.293
	0.433	0.338	0.393	0.281	0.358	0.358	0.360
	0.363	0.353	0.264	0.267	0.376	0.233	0.309
	0.259	0.093	0.276	0.317	0.471	0.297	0.286
	0.337	0.147	0.237	0.502	0.077	0.308	0.268
	0.342	0.281	0.282	0.47	0.59	0.311	0.379
Random	0.2	0.213	0.186	0.132	0.173	0.303	0.201
	0.434	0.149	0.347	0.288	0.234	0.186	0.273
	0.168	0.269	0.603	0.416	0.446	0.329	0.372
	0.287	0.283	0.196	0.156	0.23	0.392	0.257
	0.48	0.402	0.25	0.198	0.238	0.447	0.336
	0.106	0.257	0.255	0.109	0.267	0.138	0.189
	0.187	0.205	0.111	0.239	0.449	0.389	0.263
	0.31	0.372	0.325	0.28	0.44	0.374	0.350
	0.299	0.298	0.322	0.432	0.222	0.242	0.303
	0.505	0.145	0.343	0.355	0.245	0.249	0.307
	0.287	0.294	0.35	0.256	0.548	0.152	0.315

The estimation of correspondence between these research data was made by means of an analysis of variance. Initially, the normality of the samples was estimated. It is found out that both variants of studies cause a normal distribution of the ratio of the specific time of stopping to the specific time of travel (Figure 2-3). The results of the variance analysis are presented in Table 4.

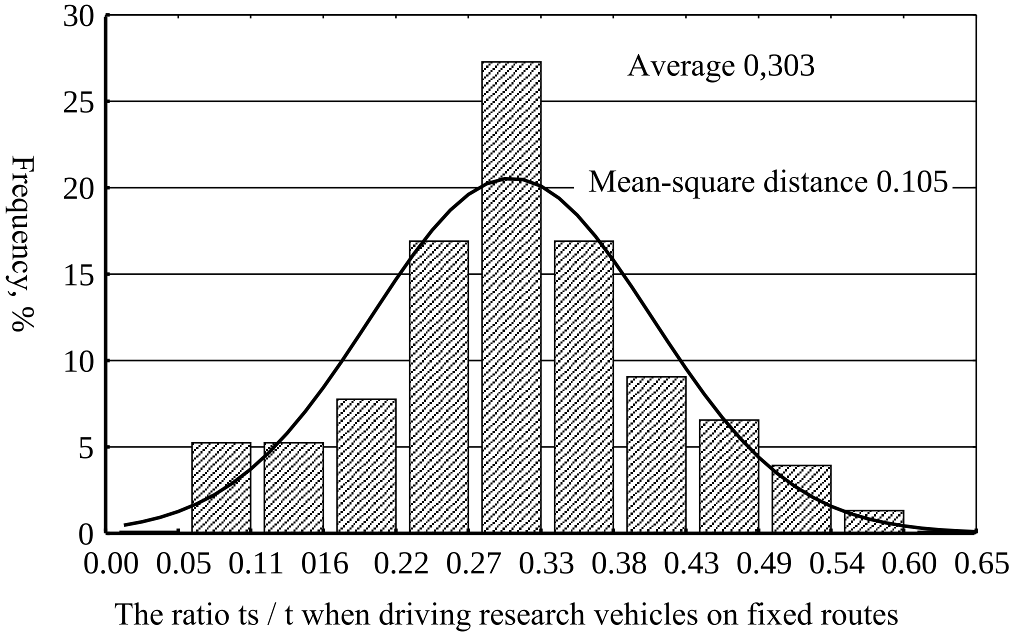

Figure 2. Common distribution of the ratio of the specific time of stopping to the specific travel time when driving along fixed routes

Table 4. The results of the variance analysis for different route choices

Sources of variation	Feedom degree	Mean-square of factors	Mean-square of error	F-criterion	Significance level
Route type (fixed- random)	20	0.00878	0.0173	0.507	0.485
Research time	6	0.00675	0.0012	5.603	0.027
Correlation	120	0.0108	0.0012	0.111	0.995

If we take into account the value of the F-criterion and the significance level, we can draw the following conclusions. The value of the F- criterion for the study time shows the significance of the influence of this factor on the value of the studied parameter - the ratio of the specific time of stopping to the specific time of travel. This is a positive quality as it testifies that during the research the conditions of traffic have changed. The values of the F- criterion for fixed and random routes show that there are no significant differences between the estimation ts/t obtained for different variants of the research. Consequently, the research variant with a random choice of "floating" cars provides real data about the traffic conditions.

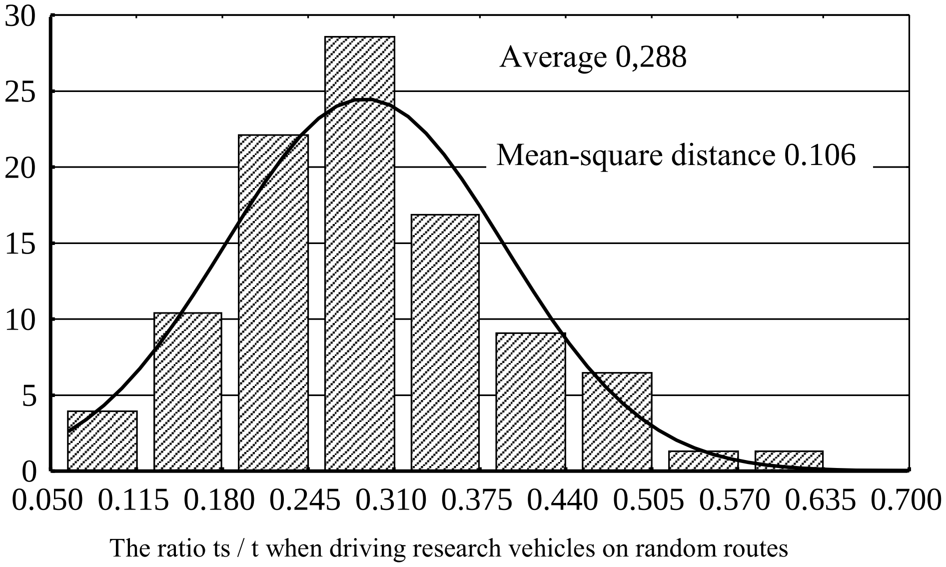

Figure 3. Common distribution of the ratio of the specific time of stopping to the specific travel time for driving along random routes

3. Conclusions

The basic correspondence between the two-component kinetic theory of the traffic flow is also made - the correspondence between the specific parameters of the travel, stopping and travelling in free conditions. This correspondence for fixed and random data is shown in Figure 4.

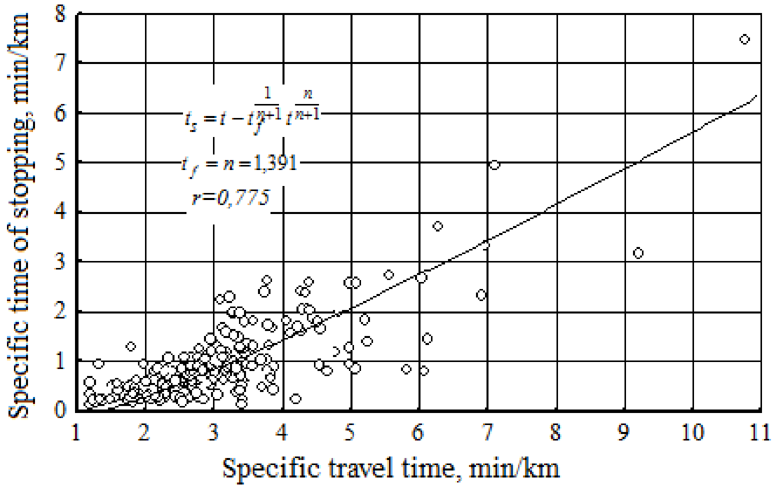

Figure 4. The correspondence between travel time and stopping according to the results of a random research

All the experimental data are obviously homogeneous. The variation of the value estimation of such an important parameter as the specific travel time in free conditions for fixed and random data is about 4.5%.

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