UCSF
UC San Francisco Previously Published Works

Title
IDENTIFICATION OF ANIMAL-VEHICLE COLLISIONS HOTSPOTS ON HIGHWAY M-18

Permalink
https://escholarship.org/uc/item/2s09m392

Journal
PROCEEDINGS OF THE NATIONAL AVIATION UNIVERSITY, 3(64)

Author
Kokhan, Oleh

Publication Date
2015-06-01

Peer reviewed

UDC 629.73:351.814.2(045)

Iaroslav Movchan [1,1]
Oleh Kokhan [1,2]
Dmytro Gulevets

IDENTIFICATION OF ANIMAL-VEHICLE COLLISIONS HOTSPOTS ON HIGHWAY M-18

[1]National Aviation University, Kyiv, Ukraine
1 Kosmonavta Komarova prospect, Kyiv, 03680, Ukraine
E-mail: [1] yaroslav.movchan@gmail.com, [2] interecocentre@gmail.com,

Abstract: *The evaluation of the deviation between of actual location of the animal-vehicle collisions actual location in the road and their models location that rounded up to a certain number for each of the models by using by three methods: a.) graphical analysis comparing the values models location on the single coordinate plane; b.) the comparison of their absolute and relative error; c.) the comparison of the class frequency for the values of the models locations.*

Keywords: model location; animal-vehicle collisions; monitoring system; identification of hotspots.

1.Introduction

Animal–vehicle collisions (AVCs) are a serious problem that can result in property damage and human and animal injury and death that increased the importance of studies of AVC locations [1, 2]. Such consequences are requires for building of predictive model for AVCs that has temporal and spatial components [3] as part of the monitoring system that has been used for identification of spatial clustering of AVC a long period of time [4]. The predictive models with reliable statistical evaluation and accuracy can be generated from government databases [5]. If the database has AVCs location with errors in records are realistic problems that often compromise accuracy of safety model outcomes [6].

2. Problem statement

The identification of crash hotspots is the first step of the highway safety management process. Errors in hotspot identification may result in the inefficient use of resources for safety improvements and may reduce the global effectiveness of the safety management process [7]. The high-risk locations or hotspots for detailed engineering study and countermeasure evaluation is the first step in a transport safety improvement program [8].

3. Analysis of previous studies

Systematically collected animal-vehicle collision data help estimate the magnitude of the problem and help record potential changes in animal-vehicle collisions over time. Such data also allow for the identification and prioritization of locations that has to require mitigation. Furthermore, systematically collected animal-vehicle collision data allow for the evaluation of the effectiveness of mitigation measures in reducing the number of animal-vehicle collisions [9]

To implement the previous provisions regarding the management and reduction of AVC is needed to developed a system of monitoring AVC, which includes the following principles [10] The article proposes to add to statistic methods for evaluate of identification of AVC [11, 12], the another method that are not popular in AVC's researches. It is graphical method of identifying of hotspots of AVC by using the graphical representation of which is investigated in our article and can be a tool for monitoring system for AVCs. After the AVC, there are some deviation determining of its location [13].

4. Method

The study has another important issue to evaluate of deviation of AVC's location. The graphical methods can use in the monitoring systems for AVC. The monitoring system with only database is limited in using its full function for monitoring. The authors have proposed to improve of the functionality of the monitoring system by using a graphical representation of AVC data. There are some problems with choice of the graphical representation of AVC data that has been solved by using of evaluation method of the deviation graphical representation of the model location AVC as additional tool for monitoring. The present study is developing a graphical representation of AVCs model location by using evaluation of the deviation between the actual location l_{0i} AVC on the road and its model location l_{0i}. Each of AVC in the road has its own individual number N_{0i} that is corresponding to the own value of the location l_{0i} on the road. Fig. 1. shows the graph of distribution 79 points of AVC that they have actual values of the locations l_{0i} and individual number N_{0i}, where i - count of AVC if i=79 the graph cannot be fully reflected all points of the values actual locations l_{0i} for each AVC. After rounding of the values actual location

l_{0i}, that were obtained in the model location l_{ni} where $n=1;2;3;4$ number of models for rounding: a.) numbers to the nearest 100 in the model $n=1$; (b.) numbers to the nearest 1000 in the model $n=2$; (c.) numbers to the nearest 10000 in the model $n=3$; d.) numbers to the nearest 100000 in the model $n=4$. For each n-models is proposed to evaluate the value of deviations $|l_{0i} - l_{ni}|$ using the following three methods: 1.) graphical analysis comparing the values models location $l_{1i}, l_{2i}, l_{3i}, l_{4i}$ on the one coordinate plane; 2.) evaluation of their absolute $\Delta(l_{ni})$ and relative error $\delta(l_{ni})$ 3.) evaluation of the class frequency f_n and of the width of the class frequency h_n from f_n after grouping numeric data by intervals $100,1000,10000, 100000$ for each of the n-models locations.

These methods are basis of graphic to represent data and authors propose add to monitoring system which has already temporal and spatial components. The article is represented of development principal of graphical representation AVCs as a part of the monitoring system. For this will be evaluated deviation between the value of the real location l_{0i} AVC on the road and its rounded value model location l_{ni}.

The study used AVC data $i = 79$ which have place in period from 18.12.2007 to 23.12.2013 on the highway M-18 in Zaporozhye region of Ukraine. Every AVC has its own individual number N_{0i} and appropriate of value of the real location of the accident L_{0i} was expressed in kilometres and metres from AVC government database. The values of L_{0i} has transformed into values l_{0i} that expressed only meters. In the Microsoft Excel values l_{0i} was rounded to values - l_{ni}, where n - is the number of model location: for $n =1$ model location is l_{1i}; for $n =2$ model location is l_{2i}; for $n =3$ model location is l_{3i}; $n =4$ model location is l_{4i}.

The value of L_{0i}, l_{0i} and l_{ni} were included in a calculation table where each records has an individual number to identification AVC N_{0i}. The calculation table has the following columns: N_{0i} - individual number of AVC; L_{0i} - reallocation of AVC from the database of AVC of the State traffic police Zaporozhye and which expressed in kilometers and meters, l_{0i} - copy column "L_{0i}" which is transformed into only meters; l_{1i} - the value of the location after rounding l_{0i} for $n=1$; l_{2i} - the value of the location after rounding l_{2i} for $n=2$; l_{3i} - the value of the location after rounding l_{3i} for $n=3$; l_{4i} - the value of the location after

rounding l_{0i} for $n=4$. The data for all model location $n=1,2,3,4$ are summarized in Microsoft Excel's Table 1.

Table 1.The result of calculation table for the values of the location l_{0i} accident and after rounding to the values of the models location $l_{1i}, l_{2i}, l_{3i}, l_{4i}$.

Number of models, n	l_{1i}	l_{2i}	l_{3i}	l_{4i}
Class frequency, l_{ni}	75	60	19	3
Amount of AVC, i	79	79	79	79

To evaluation the deviation between the value actual location l_{0i}, and value model location l_{ni}, were used the following methods: 1.) the graphical analysis comparing the values of the point of models location $l_{1i}, l_{2i}, l_{3i}, l_{4i}$ on the one coordinate plane; 2.) the comparison of their absolute $\Delta(l_{ni})$ and relative error $\delta(l_{ni})$; c.) the comparison of the class frequency f_n for the values of the models locations and the width of the class frequency h_n after grouping numeric data by intervals $100,1000,10000, 100000$ for each of the n-models locations.

4.1. Comparing the values models location on the single coordinate plane

For the first evaluation method: graphical analysis comparing the values l_{1i}, for columns l_{1i}, l_{2i}, l_{3i}, l_{4i} from Table 1 were constructed graphs of distribution of point of models location of AVC on each coordinate plane for $n=1,2,3,4$ (Fig. 1. Fig. 2., Fig. 3., Fig. 4.).
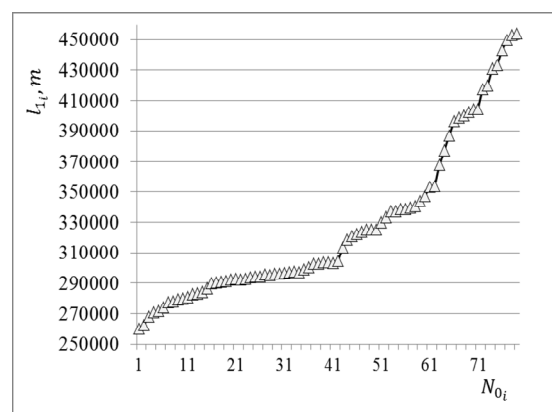

Fig. 1.Graph with a points of the distribution of values of model locations l_{1i} for $n=1$ for N_{0i} AVC
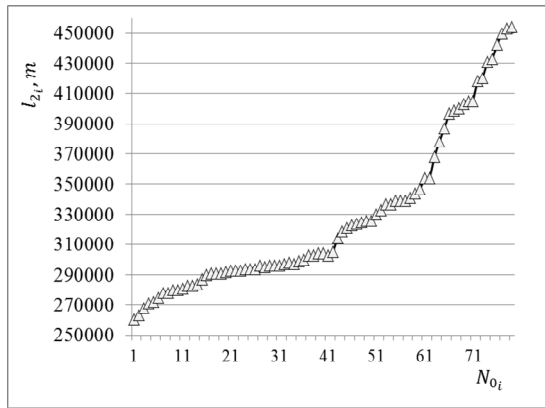
Fig. 2. Graph with a point of the distribution of values of model locations l_{1i} for $n=2$ for N_{0i} AVC
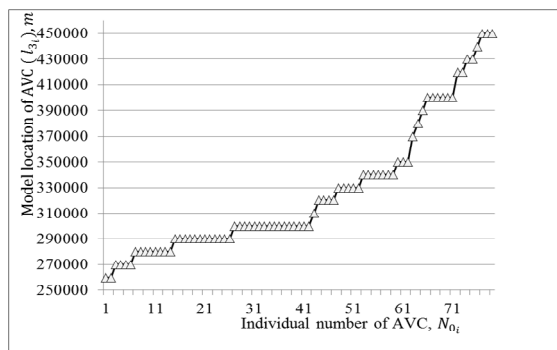

Fig. 3. Graph with a point of the distribution of values of model locations l_{0i} for $n=3$ for N_{0i} AVC
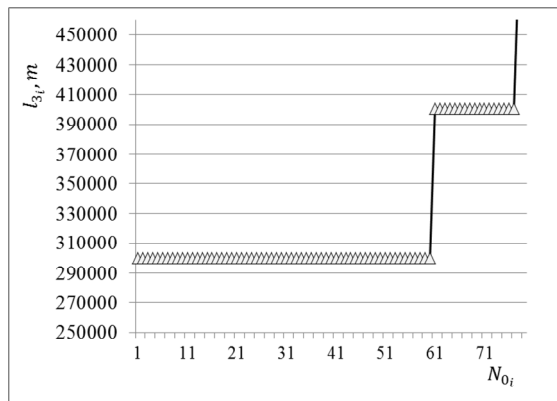

Fig. 4. Graph with a point of the distribution of values of model locations l_{4i} for $n=4$ for N_{0i} AVC

4.2. The comparison of absolute and relative error

The second method of evaluation of the deviation between l_{0i} and l_{ni} using the calculations of the absolute error $\Delta(l_{ni})$ and relative error $\delta(l_{ni})$ was prepared in the Table 2. The calculation of the absolute error $\Delta(l_{ni})$ and relative error $\delta(l_{ni})$ for is held by the formulas (2) and (3):

$$\Delta(l_{ni}) = |l_{0i} - l_{ni}| \qquad (1)$$

$$\delta(l)_{ni} = \frac{|l_{0i} - l_{ni}|}{l_{ni}} \qquad (2)$$

The data for all models location $n=1,2,3,4$ are summarized in Microsoft Excel's Table 2.

Table 2. Calculation of the absolute error $\Delta(l_{ni})$ and relative error $\delta(l_n)$ for n-models.

Name	$\Delta(l_{1i})$	$\delta(l_{1i})$	$\Delta(l_{2i})$	$\delta(l_{2i})$	$\Delta(l_{3i})$	$\delta(l_{3i})$	$\Delta(l_{4i})$	$\delta(l_{4i})$
i	79	79	79	79	79	79	79	79
MIN	0	0	0	0	150	0,033	150	0,05
MAX	50	0,02	500	0,17	4950	1,677	49850	15,27

MIN - minimum values; MAX - maximum values that selected from $\Delta(l_{1i})$ and $\delta(l_{ni})$ for $n=1,2,3,4$; i - amount of AVC.

4.3. Comparison of the class frequency for the values of the models locations.

The third method evaluation of the deviation between l_{0i} and l_{ni} by calculating the class frequency f_n for the values of the models location l_{ni} and of the width of the interval grouped h_n for $n=1,2,3,4$ that are presented in Table 1.

For each group lni for n-models create the distribution graph of the class frequency fn for model location lni (Fig. 5. Fig. 6., Fig. 7., Fig. 8.). Graph of the group for the model l1i shown in Fig. 6.
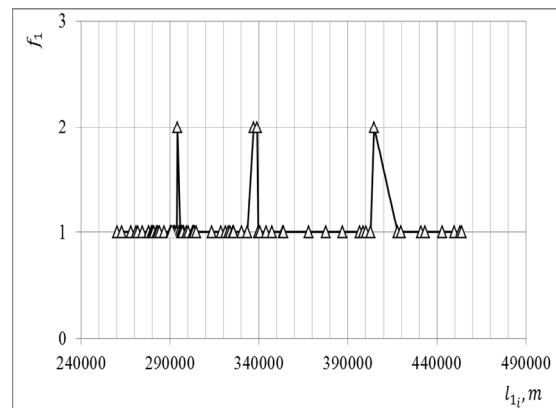

Fig. 5. The graph of the distribution of the class frequency f_1 for model locations l_{1i} for $n=1$.

The graph of the distribution of the class frequency f_1 for locations l_{2i} for $n=2$ shown in Fig. 6.
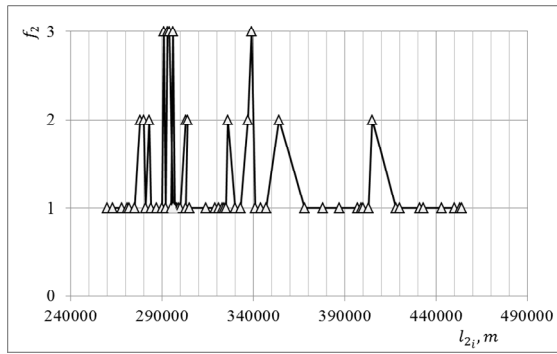
Fig.6. The graph of the distribution of the class frequency f_2 for model location l_{2i} for $n=2$ The graph of the distribution of the class frequency f_3 for locations l_{3i} for $n=3$ shown in Fig. 7.
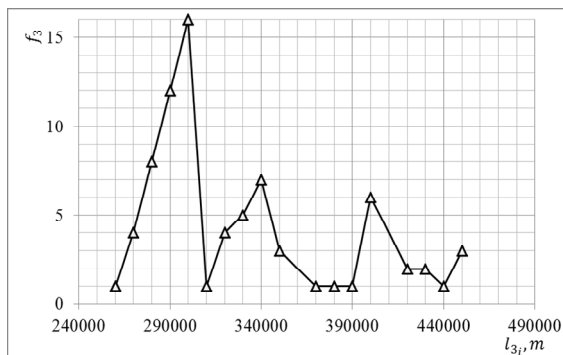

Fig. 7. The graph of the distribution of the class frequency f_3 for model location l_{3i} for $n=3$

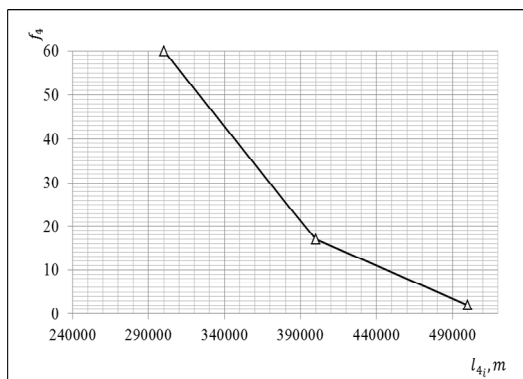The graph of the distribution of the class frequency f_4 for locations l_{4i} for $n=4$ shown in Fig. 8.

Fig. 8. The graph of the distribution of the class frequency f_4 for the model locations l_{4i} for $n=4$ the models locations l_{1i}, l_{2i}, l_{3i}, l_{4i} that has $n=1;2;3;4$ from AVC individual number N_{0i} Note: Fig. 9 has not two points $i=78$ and $i=79$ for $n=4$ models locations l_{4i}.

5. Results

1.) Graphical analysis on the coordinate plane graphs of the distributions of the values of the models locations l_{1i}, l_{2i}, l_{3i}, l_{4i} from individual accidents N_{0i} in Fig. 9.
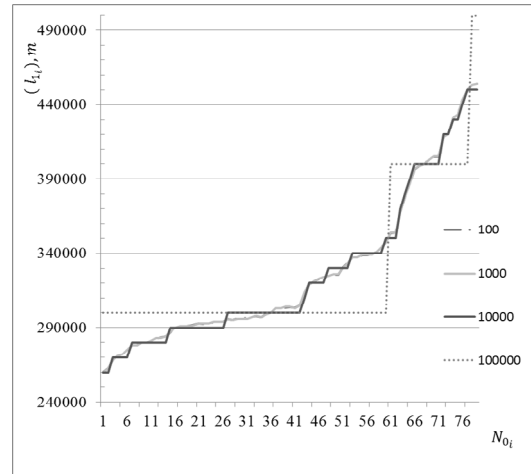

Fig. 9. Graphical analysis on the coordinate plane graphs with points of the distributions of the values of the models locations l_{1i}, l_{2i}, l_{3i}, l_{4i} from individual accidents N_{0i}.

2.) The second evaluation method on the coordinate plane graphs of the relative error $\delta(l_1)$, $\delta(l_2)$, $\delta(l_3)$, $\delta(l_4)$ for n-models in shows in Fig. 10. There are very significant difference data for the absolute error $\Delta(l_{ni})$ for $n=1$ and $n=4$ they were not to show in graphic.
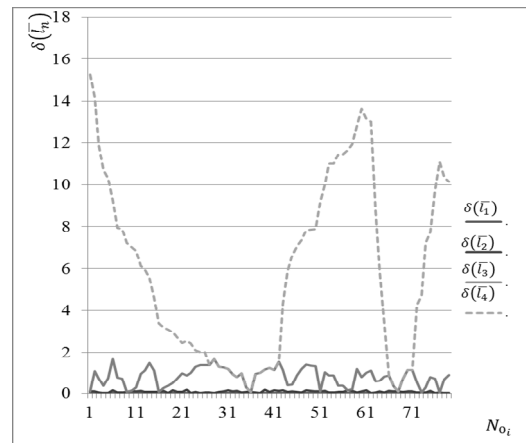

Fig. 10. Graphs of values $\delta(l_1)$, $\delta(l_2)$, $\delta(l_3)$, $\delta(l_4)$ in the Table 2 for each of the individual numbers of AVCs N_{0i}.

3.) The third method evaluation of the deviation between l_{0i} and l_{ni} was calculated the f_n – class frequency are grouped by the value model locations l_{1i}, l_{2i}, l_{3i}, l_{4i} from the Table 2, and the width of the class frequency h_n grouping numeric data by intervals $100,1000,10000, 100000$ for each of $n=1;2;3;4$. To calculate the class interval h_n for each n-model by using (3).

$$h_n = \frac{N_{max} - N_{min}}{N_n} \qquad (3)$$

where h_n - class interval; N_{max}- upper class limit at the groups AVC for each n; N_{min} - lower class limit value of the amount at the groups AVC for each n. Data for calculating the width of the interval grouping for each model are given in Table 3.

Table 3. The evaluation of the results of the three methods for models $n=1,2,3,4$.

Name/ models	l_{1i}	l_{2i}	l_{3i}	l_{4i}
Upper class limit, N_{max}	2	3	16	60
Lower class limit, N_{min}	1	1	1	2
Range, N_{max} -N_{min}	1	2	15	58
Class frequency, f_n	75	60	19	3
Count of AVC, N_{0i}	79	79	79	79
Class interval, h_n	0,013	0,033	0,788	19,33
Absolute error, Min, $\Delta(l_{ni})$	0	0	150	150
Absolute error, Max, $\Delta(l_{ni})$	50	500	4950	49850
Relative error, Min, $\delta(l_n)$,	0,00	0,00	0,033	0,050
Relative error, Max, $\delta(l_n)$,	0,019	0,171	1,677	15,2738

Graph of the dependence for the class interval h_n from class frequency f_n for n-models are shown in Fig. 11.
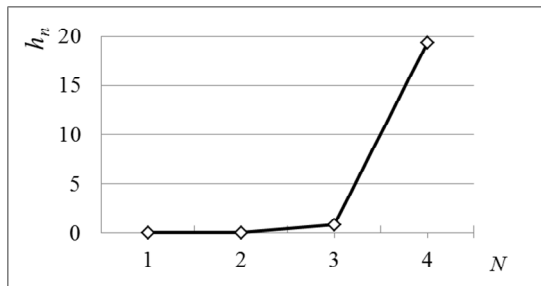

Fig. 11. Graph of the of the dependence of the class interval h_n from class frequency f_n for n-models

Discussion

1. The graphs of the animal–vehicle collisions (AVC) для models location має next values:

- for model location l_{1i}, in the next distance of the graphs there are:

in the distance $250000 \le l_{1i}, \le 300000$ the AVC individual numbers are $1 \le N_{0i} \le 36$ and AVC count is $i=36$;

in the distance $300000 \le l_{1i}, \le 350000$ the AVC individual numbers are $37 \le N_{0i} \le 61$ and AVC count is $i=25$;

in the distance $350000 \le l_{1i}, \le 400000$ the AVC individual numbers are $37 \le N_{0i} \le 68$ and AVC count is $i=7$;

in the distance $400000 \le l_{1i} \le 450000$ the AVC individual numbers are $69 \le N_{0i} \le 79$ and AVC count is $i=9$.

Total count AVC is $i=79$ for model location l_{1i}.

The model location l_{1i}, is have enough of count AVC individual numbers in the monitoring systems graph. But not all the points can be seen on the AVC graph.

- for model location l_{2i},:

in the distance $250000 \le l_{2i}, \le 300000$ the AVC individual numbers are $1 \le N_{0i} \le 36$ and AVC count is $i=36$;

in the distance $300000 \le l_{2i} \le 350000$ the AVC individual numbers are $37 \le N_{0i} \le 62$ and AVC count is $i=26$;

in the distance $350000 \le l_{2i} \le 400000$ the AVC individual numbers are $63 \le N_{0i} \le 68$ and AVC count is $i=6$;

in the distance $400000 \le l_{2i} \le 450000$ the AVC individual numbers are $69 \le N_{0i} \le 79$ and AVC count is $i=11$.

Total count AVC is $i=79$ for model location l_{2i}.

The model location l_{2i} is have enough of count AVC individual numbers in the monitoring systems graph. But not all the points can be seen on the AVC graph.

- for model location l_{3i}:

in the distance $250000 \le l_{3i} \le 300000$ the AVC individual numbers are $1 \le N_{0i} \le 42$ and AVC count is $i=42$;

in the distance $300000 \le l_{3i} \le 350000$ the AVC individual numbers are $43 \le N_{0i} \le 62$ and AVC count is $i=20$;

in the distance $3500000 \le l_{3i} \le 400000$ the AVC individual numbers are $63 \le N_{0i} \le 71$ and AVC count is $i=9$;

in the distance $400000 \le l_{3i} \le 450000$ the AVC individual numbers are $72 \le N_{0i} \le 79$ and AVC count is $i=8$;

Total count AVC is $i=79$ for model location l_{3i}.

The model location l_{3i} has enough of count AVC individual numbers in the monitoring

systems graph. All the points can be seen on the AVC graph.

- for model location l_{4i}:

in the distance $250000 \leq l_{4i} \leq 300000$ the AVC individual numbers are $1 \leq N_{0i} \leq 60$ and AVC count is $i=60$;

in the distance $300000 \leq l_{4i} \leq 350000$ the AVC individual numbers are $61 \leq N_{0i} \leq 77$ and AVC count is $i=17$;

in the distance $350000 \leq l_{4i} \leq 400000$ the AVC individual numbers are $78 \leq N_{0i} \leq 79$ and AVC count is $i=2$;

Total count AVC is $i=79$ for model location l_{4i}.

The model location l_{4i} has very small point in the AVC monitoring systems graph. All the points can be seen on the AVC graph.

2. The graphs of values relative error $\delta(l_{ni})$, for models locations is $0 \leq \delta(l_{ni}) \leq 1$; $0 \leq \delta(l_{ni}) \leq 1$; $0 \leq \delta(l_{ni}) \leq 2$; $0 \leq \delta(l_{ni}) \leq 16$. The models location l_{1i}, l_{2i}, l_{3i}, is accurate for monitoring systems graph. The model location l_{4i} is inaccurate for monitoring systems graph.

3. The graphs of the distribution of the class frequency f_1 for model location l_{1i} has the following values: lower class limit $N_{min}=1$, upper class limit $N_{max}=2$ in the next point of models location l_{1i}: $290100, 337100, 404600$. The graphs of the distribution of the class frequency f_2 per model location l_{2i} has the following values: lower class limit $N_{min} = 1$, upper class limit $N_{max} =3$ in the next point of models location l_{2i} $290000, 339000$. The graphs of the distribution of the class frequency f_3 per model location l_{3i} has the following values: lower class limit $N_{min}=1$, upper class limit $N_{max} =16$ and the next class frequency: $f_3 =16$ in the point of model location is $l_{3i}=300000$ $f_3 =7$ in the point of model location $l_{3i}=340000$ $f_3 =6$ in the point of model location $l_{3i}=400000$ $f_3 =3$ in the point of model location $l_{3i}=450000$. The graphs of the distribution of the class frequency f_4 for model location l_{4i} has the following values: lower class limit $N_{min} = 1$, upper class limit $N_{max} =60$ and the next class frequency: $f_4=60$ in the point of model location is $l_{4i}=450000$ $f_4=17$ in the point of model location $l_{4i}=400000$ $f_3 =2$ in the point of model location $l_{4i}=500000$. The class interval for $1,2,3$-models is $h_n \leq 1$ that is an acceptable result for monitoring systems. The class interval for 4-models is $h_n =19,3$ that is an unacceptable result for monitoring systems.

6. Conclusions

Four models location can be used in the monitoring system as four modes, ranging from $n = 1$ as "minimal deviation and minimum class frequency " and ending with $n = 4$ as "maximum deviation and maximum class frequency . Using the $n = 1$ "minimum deviation and minimum class frequency " allows to use monitoring of the animal vehicle collisions that has approach to the real location, and in case $n = 4$ deviation of location - has a maximum value and maximum concentration of point. In the case $n = 4$ mode as "maximum deviation and maximum class frequency f_n has count of class frequency f_n the minimum value that makes it impossible use the graph in the monitoring system the number of locations AVC, allowing to identify the location on the highway, where the greatest number of hot spots of animal–vehicle collisions in the road M-18 in Ukraine. Deviations between l_{0i} and l_{ni} in models location $n=2$ and $n=3$ are the most optimal to represent the value of the location l_{ni} as the characteristics of the AVC monitoring system.

References

[1] *Jensen R. R.* Landscape factors that contribute to animal–vehicle collisions in two northern Utah canyons/ *Ryan R. Jensen, Rusty A. Gonser, Christian Joyner*// Applied Geography. – 2014. – #6. – P. 74-79.

[2] Wildlife-vehicle collision reduction study. Report to Congress. U.S. Department of Transportation/ *M. P. Huijser* [et al.] – Washington: Federal Highway Administration, 2007. – 254 p.

[3] *Rodríguez-Morales B.* Spatiotemporal analysis of vehicle collisions involving wild boar and roe deer in NW Spain/ *Beatriz Rodríguez-Morales, Emilio Rafael Díaz-Varela, Manuel Francisco Marey-Pérez*//Accident Analysis & Prevention. – 2013. – #60. – P. 121-133.

[4] Assessing methods of mitigating wildlife–vehicle collisions by accident characterization and spatial analysis/ *Emilio R. Diaz-Varela,* [et al.]// Transportation Research Part D: Transport and Environment. – 2011. – #16 (4). – P.281-287.

[5] *Snow P. N.* Underreporting of wildlife-vehicle collisions does not hinder predictive models for large ungulates/ *Nathan P. Snow*, [et al.]// Biological Conservation. – 2015. – #181. – , P. 44-53.

[6] *Tegge R.A.* Correcting erroneous crash locations in transportation safety analysis/ *R.A.Tegge, Y. Ouyang* // Accident Analysis and Prevention. – 2008. – #41(1). – P.202– 209.

[7] *Alfonso Montella.* A comparative analysis of hotspot identification methods/ Accident Analysis & Prevention. – 2010. – #42 (2). P. 571-581.

[8] *Miranda-Moreno L. F.* Bayesian multiple testing procedures for hotspot identification/ *Luis F. Miranda-Moreno, Aurélie Labbe, Liping Fu*// Accident Analysis & Prevention. – 2007. – #39 (6). – P. 1192-1201.

[9] Animal-Vehicle Collision Data Collection Throughout the United States and Canada". In Proceedings of the 2007 International Conference on Ecology and Transportation/ *M.Huijser*, [et al.]. – Raleigh:Center for Transportation and the Environment., 2007. – 391 p.

[10] California's Integrated Approach to Collaborative Conservation in Transportation Planning. In Proceedings of the 2007 International Conference on Ecology and Transportation/ *G. Erickson.* – Raleigh:Center for Transportation and the Environment., – 2007. – 257 p.

[11] *Lord D.* The statistical analysis of crash-frequency data: A review and assessment of methodological alternatives/ *Dominique Lord, Fred Mannering*//Transportation Research Part A: Policy and Practic. – 2010. – # 44(5). – P. 291-305.

[12] *Mannering F. L.* Analytic methods in accident research: Methodological frontier and future directions/ *Fred L. Mannering, Chandra R. Bhat*// Analytic Methods in Accident Research. – 2014. – #1. – P. 1–22.

[13] *Gunson K.E.* Large animal-vehicle collisions in the Central Canadian Rocky Mountains: patterns and characteristics. IN: Proceedings of the 2003 International Conference on Ecology and Transportation/ *K.E. Gunson, B. Chruszcz and A.P. Clevenger.* – Raleigh: Center for Transportation and the Environment, 2004. – 366 p.