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ANALYSIS OF NAVIGATION DATA BY ARTIFICIAL NEURAL NETWORKS FOR DEVELOPMENT OF DECISION-MAKING SUPPORT SYSTEMS

**Andrii Ben, PhD, professor, Pavlo Nosov PhD,
Ihor Palamarchuk PhD, Anton Fedorov PhD**

In difficult navigation conditions, there arise situations associated with multifactoriality [1,2]. The navigator experiences difficulties in such situations, especially if he does not have sufficient experience [3]. This happens when the situation that has arisen is close in its context to those ones that were encountered earlier, but in reality, differs in its parameters [4].

In such situations, the navigator has a high probability of error. Considering the limitations of the size of the locations and the ship's inertia, a tactical error while performing a maneuver can have negative consequences [5]. In order to prevent such incidents while sailing, it is necessary to create decision support systems. You also need to take into account the large amount of navigation data that arrive at the captain's bridge at the same time [6,7]. Such data are difficult to process in real time using standard statistical methods. To process them, it is necessary to use more complex systems that are based on the use of artificial neural networks.

Let us consider the implementation of this task in the form of a classification of the phases of a previously identified navigation situation in the port of Dover. The problem of comparing incoming navigation data with previously formalized hazardous situations associated with discrepancies with several ships is considered.

A method is proposed for using automated neural networks for processing a multifactor array of navigation data when performing complex maneuvers:

1. Give the priority of the operation of decision-making moments in taking into account ships - targets in the immediate radius, it is proposed to form the situation in the perspective of phases of events.

2. There are four phases of the situation and codes for training (Train) and control (Select) samples;

3. Consider the feature space for navigation data. To do this, build a graph of categories - scattering diagrams with overlap.

4. Then, select the variables for the primary classification of the situation (Fig. 1).

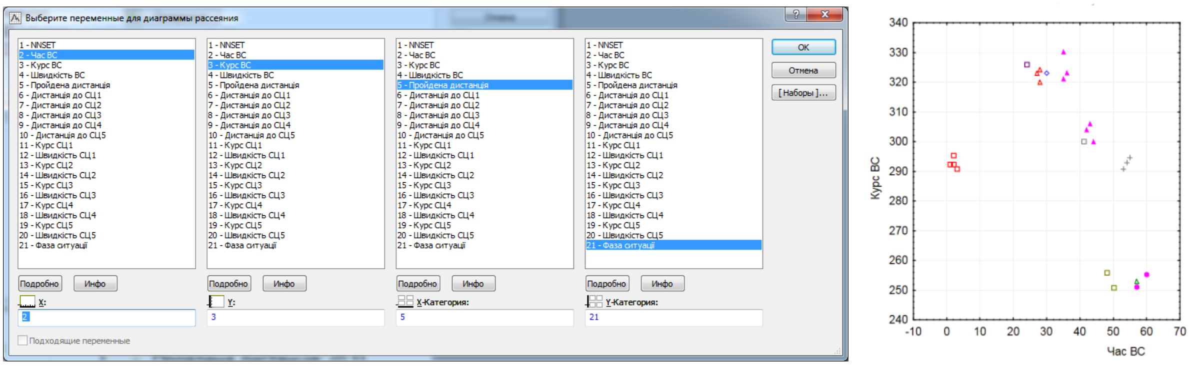

Fig. 1. Graph data for primary classification

As it can be seen from the graph, the navigation situations are visually well separated in relation to the "Phases of the situation". Thus, a preliminary analysis of the data showed that the task can be classified as areas of display of classification features that are logically related.

5. For a deeper analysis of the data, with their number of variables, it was decided to build neural network classification models (Fig. 2).

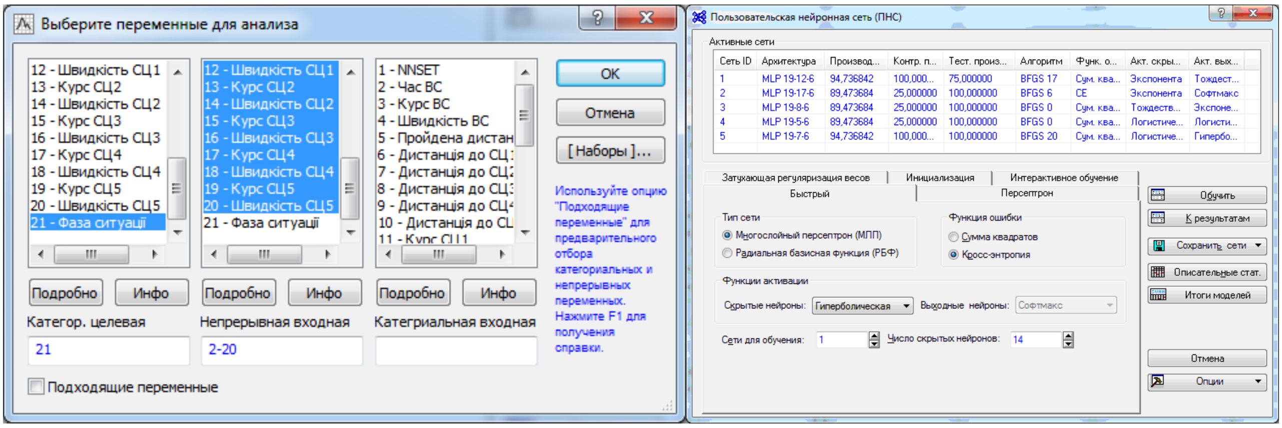

Fig. 2. Adjust the feature space for classification

The obtained data indicate high accuracy of modeling.

6. We will conduct an interactive study of the neural network based on 1000 epochs of modeling. As you can see, network performance ranges from 84 to 100%, which is quite high in a large array of navigation data.

7. Next, build multiple subsamples. Let's increase the data of the neural network: up to 2000 epochs and the number of hidden neurons - 20. This will clarify the elements of network modeling based on a multilayer perceptron.

The obtained data indicate a deeper processing of the neural network MLP 19-25-6 with performance indicators of 94.7%. Thus, this network can be taken as a basis for identifying the phases of the navigation situation in the port area of Dover.

8. Thus, we choose the most effective neural network model №7 and perform its detailed analysis (Fig. 3).

Описательные статистики
Нейросеть: 7.MLP 19-25-6

Выборки	Час ВС Вход	Курс ВС Вход	Швидкість ВС Вход	Пройдена дистанція Вход	Дистанція до СЦ1 Вход	Дистанція до СЦ2 Вход	Дистанція до СЦ3 Вход	Дистанція до СЦ4 Вход	Дистанція до СЦ5 Вход
Минимум (Обучающая)	1,00000	251,0000	0,00000	0,000000	0,00000	0,000000	0,00000	0,000000	0,000000
Максимум (Обучающая)	60,00000	330,2000	10,00000	8,800000	12,00000	9,000000	11,00000	7,000000	1,300000
Среднее (Обучающая)	30,78947	298,5000	7,35263	4,201053	3,75789	2,703158	2,33158	1,254737	0,210526
Стандартное отклонение (Обучающая)	20,51714	24,4482	2,36064	3,182371	3,81070	2,897066	3,15578	2,068610	0,472458
Минимум (Контрольная)	28,00000	251,1000	4,00000	4,310000	0,00000	0,000000	0,00000	0,000000	0,000000
Максимум (Контрольная)	60,00000	324,2000	8,00000	7,830000	6,00000	9,000000	3,00000	3,000000	0,160000
Среднее (Контрольная)	46,75000	283,6500	6,17500	6,162500	2,00000	2,550000	0,75000	0,750000	0,065000
Стандартное отклонение (Контрольная)	14,77329	36,1555	1,98053	1,816726	2,82843	4,337050	1,50000	1,500000	0,078951
Минимум (Тестовая)	43,00000	253,0000	5,00000	4,900000	0,00000	0,000000	0,00000	0,000000	0,000000
Максимум (Тестовая)	57,00000	306,0000	8,00000	7,300000	6,00000	9,000000	5,00000	0,700000	1,300000
Среднее (Тестовая)	49,50000	288,0000	6,55000	6,050000	3,00000	4,500000	2,00000	0,175000	0,400000
Стандартное отклонение (Тестовая)	31,38471	28,5397	2,58392	3,806810	2,99110	4,228475	2,88444	1,665083	0,591608
Минимум (Пропущенные)									
Максимум (Пропущенные)									
Среднее (Пропущенные)									
Стд (Пропущенные)									
Минимум (Общий)	1,00000	251,0000	0,00000	0,000000	0,00000	0,000000	0,00000	0,000000	0,000000
Максимум (Общий)	60,00000	330,2000	10,00000	8,800000	12,00000	9,000000	11,00000	7,000000	1,300000
Среднее (Общее)	35,92593	294,7444	7,05926	4,765556	3,38519	2,946667	2,04815	1,020000	0,217037
Стандартное отклонение (Общее)	19,69757	25,8255	2,17242	2,892602	3,57499	3,396328	2,85743	1,843250	0,455891

Выборки	Курс СЦ1 Вход	Швидкість СЦ1 Вход	Курс СЦ2 Вход	Швидкість СЦ2 Вход	Курс СЦ3 Вход	Швидкість СЦ3 Вход	Курс СЦ4 Вход	Швидкість СЦ4 Вход	Курс СЦ5 Вход	Швидкість СЦ5 Вход
Минимум (Обучающая)	0,0000	0,000000	0,00000	0,000000	0,0000	0,00000	0,0000	0,000000	0,0000	0,000000
Максимум (Обучающая)	114,0000	8,000000	90,00000	8,000000	227,0000	14,20000	300,0000	8,300000	132,0000	6,000000
Среднее (Обучающая)	58,7895	4,021053	26,26842	4,568421	73,1053	4,07368	58,5632	2,389474	20,3684	1,147368
Стандартное отклонение (Обучающая)	51,6281	3,403361	27,98529	3,290399	98,9618	5,58260	111,4246	3,153639	41,6443	2,289194
Минимум (Контрольная)	0,0000	0,000000	0,00000	0,000000	0,0000	0,00000	0,0000	0,000000	0,0000	0,000000
Максимум (Контрольная)	112,5000	7,000000	90,00000	7,000000	110,0000	5,00000	0,5000	8,000000	135,0000	6,500000
Среднее (Контрольная)	46,1250	3,000000	28,12500	3,500000	27,5000	1,25000	0,1250	2,000000	67,0000	3,125000
Стандартное отклонение (Контрольная)	55,7679	3,559026	42,59181	4,041452	55,0000	2,50000	0,2500	4,000000	77,3692	3,614208
Минимум (Тестовая)	0,0000	0,000000	0,00000	0,000000	0,0000	0,00000	0,0000	0,000000	0,0000	0,000000
Максимум (Тестовая)	74,0000	5,000000	94,00000	7,000000	115,0000	5,00000	294,0000	4,000000	137,0000	6,000000
Среднее (Тестовая)	36,2500	2,500000	46,50000	3,500000	56,7500	2,50000	73,5000	1,000000	55,5000	2,875000
Стандартное отклонение (Тестовая)	68,9354	4,203173	42,72587	4,041452	112,5015	7,09460	149,9286	4,472136	66,7108	3,204814
Минимум (Пропущенные)										
Максимум (Пропущенные)										
Среднее (Пропущенные)										
Стд (Пропущенные)										
Минимум (Общий)	0,0000	0,000000	0,00000	0,000000	0,0000	0,00000	0,0000	0,000000	0,0000	0,000000
Максимум (Общий)	114,0000	8,000000	94,00000	8,000000	227,0000	14,20000	300,0000	8,300000	137,0000	6,500000
Среднее (Общее)	53,5741	3,644444	29,54074	4,251852	63,9259	3,42222	52,1185	2,125926	32,4815	1,696296
Стандартное отклонение (Общее)	49,8106	3,288012	33,71390	3,392908	88,8728	4,94223	107,7276	3,072658	52,8134	2,675743

Fig. 3. Analysis of the effectiveness of the network 7 MLP 19-25-6

Analyzing the distribution of "Unidentified" situations, we can see that the distribution is quite significant, in turn, the distribution of distances to the courts of objectives 1.2 shows that the situations have their localized centers, characteristic of the phases of maneuvers. Thus, to identify situations, it will be sufficient to form models according to the parameters of distances to the nearest target vessels in the field of radar display or ECDIS. In turn, an indirect sign, with a normal distribution, for identification can be the course of your own ship, the distance and the course of the nearest ship - the target. This feature coincides with the rules of the MPPSS on the observation and execution of maneuvers while controlling the movement of the vessel (Fig. 4).

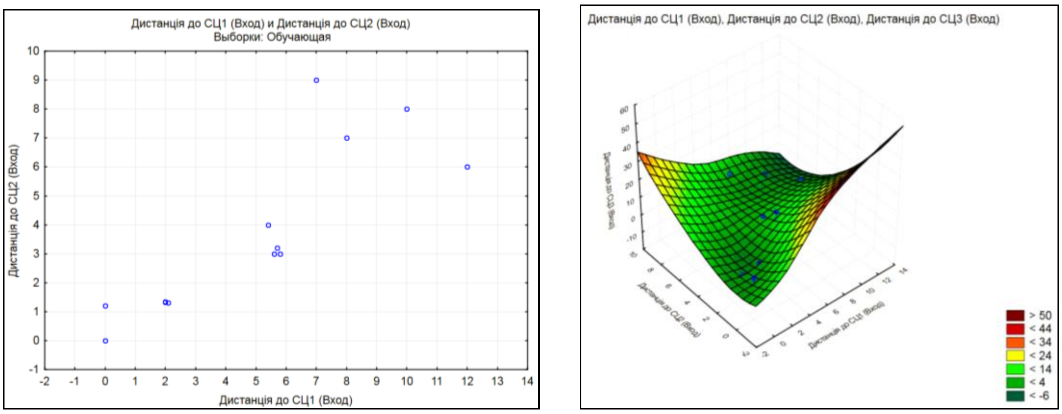

Fig. 4. Graph of identification of phases of navigation situation in difficult navigation conditions

Thus, the process of modeling and classification of the phase of the navigation situation was carried out at a sufficiently high level, as evidenced by the obtained data of automated neural networks. The obtained models make it possible to predict the occurrence of dangerous situations and their phases in the conditions of on-line observations of data of navigation information networks.

REFERENCES

10. Nosov, P. S., Cherniavskyi, V. V., Zinchenko, S. M., Popovych, I. S., Nahrybelnyi Y. A., & Nosova, H. V. (2021). IDENTIFICATION OF MARINE EMERGENCY RESPONSE OF ELECTRONIC NAVIGATION OPERATOR . Radio Electronics, Computer Science, Control, (1), 208–223. https://doi.org/10.15588/1607-3274-2021-1-20
11. Serhii Zinchenko, Vadym Mateichuk, Pavlo Nosov, Ihor Popovych, Oleksandr Solovey, Pavlo Mamenko, Olga Grosheva. Use of simulator Equipment for the development and testing of vessel control system // Electrical, Control and Communication Engineering. Sciendo. Riga technical university. 2021. Vol. 16, Nom. 2, P. 58-64. https://doi.org/10.2478/ECCE-2020-0009
12. Maltsev, S. E. (2019). Navigation device for decision-making support for the automatic planning of vessel movement by trajectory points at entry / exit of the port. Category: marine navigational systems. Science and Education a New Dimension, VII(206) (25), 42–47. doi: https://doi.org/10.31174/send-nt2019-206vii25-106
13. Zinchenko S., Ben A., Nosov P., Popovych I., Mateichuk V., Hrosheva O. The vessel movement optimisation with excessive control // Bulletin of University of Karaganda. Technical Physics, 2020. - № 3(99). P. 86-96. https://doi.org/10.31489/2020Ph3/86-96
14. Shevchenko, R., Cherniavskyi, V., Zinchenko, S., Palchynska, M., Bondarevich, S., Nosov, P. & Popovych, I. (2020). Research of psychophysiological features of response to stress situations by future sailors. Revista Inclusiones, Vol: 7 num Especial. pp. 566-579.
15. Nosov, P., Zinchenko, S., Ben, A., Prokopchuk, Y., Mamenko, P., Popovych, I., Moiseienko, V., Kruglyj, D. (2021). Navigation safety control system development through navigator action prediction by Data mining means. Eastern-European Journal of Enterprise Technologies, 2 (9 (110)), 55–68. https://doi.org/10.15587/1729-4061.2021.229237
16. Nosov P., Cherniavskyi V., Zinchenko S., Popovych I., Prokopchuk Y., Safonov M. Identification of distortion of the navigator's time in model experiment // Bulletin of University of Karaganda. Instrument and experimental techniques, 2020. - № 4(100). P. 57-70. https://doi.org/10.31489/2020Ph4/57-70