UDC 004.942:656.61.052

AUTOMATIC DETERMINATION OF THE NAVIGATORS MOTIVATION MODEL WHEN OPERATING WATER TRANSPORT

Nosov P. S. – PhD, Associate Professor of Navigation Department, Kherson State Maritime Academy, Ukraine.

Popovych I. S. – Dr. Sc., Professor of the Department of Psychology, Kherson State University, Ukraine.

Zinchenko S. M. – PhD, Associate Professor of Ship Handling Department, Head of the laboratory of electronic simulators, Kherson State Maritime Academy, Ukraine.

Kobets V. M. – Dr. Sc., Full Professor of the Department of Informatics, Software Engineering and Economic Cybernetics, Kherson State University, Ukraine.

Safonova A. F. – PhD, Associate Professor of the Department Fundamental disciplines, Kherson Polytechnic Special College of Odessa Polytechnic State University, Ukraine.

Appazov E. S. – PhD, Associate Professor of Innovative Technologies and Technical Devices of Navigation Department, Kherson State Maritime Academy, Ukraine.

ABSTRACT

Context. The article proposes an approach for automated identification of the navigators motivational model in the control of water transport. Algorithms for data extraction as a result of the man-machine interaction of navigator with the electronic control systems of the vessel during performing navigation operations of increased complexity are proposed.

Objective. The purpose of research is to apply formal and algorithmic approaches to extracting data on the motivational model of navigator to prevent accidents in water transport.

Method. The identification of manifestation determination of navigators' mental activity by means of the visual concept of the geometric group theory is proposed. This approach delivered the visual systematic-logical combining of diagnostic methods aimed at determining navigators motivational centers and the processes of professional activity like maneuver performing. The key indicator of identification is said to be the parameter of the navigator's activity as "rpm_port" having an impact on the vessel speed being a marker of intensification of the navigator's physiological activity. Such an approach is beneficial in time phase identification while maneuvering indicating explicitly at the stepping up of the navigator's physiological motivational state. It was proven to be correct based on the results due to Ward's dendrogram, several statistical methods and applied software. The obtained research results encourage the prediction of the navigator' motivational states in critical situations.

Results. In order to confirm the proposed formal-algorithmic approach, an experiment was carried out using the navigation simulator Navi Trainer 5000. Automated analysis of experimental ones made it possible to form a motivational map of the navigator and determine the decision-making model affecting in the processes of control vessel in difficult situations.

Conclusions. The proposed research approaches made it possible to automate the processes of extracting data indicating the principles of decision-making by navigator. The effectiveness of proposed approach was substantiated by the results of experimental data automated processing and the constructed tree-like decision-making spaces.

KEYWORDS: motivation identification systems, automated data processing systems, modeling of decision making models, computer simulators, analysis of the human factor, automated control systems.

ABBREVIATIONS

ECDIS is an Electronic Chart Display and Information System;

ARPA is an automatic radar plotting aid;

AIS is an Automatic Identification System;

GPS is a Global Positioning System;

NTPRO 5000 is a navigation simulator "Navi Trainer 5000";

ANOVA is an Analysis of Variance;

MMS is mental motivational states;

LNE is a level of navigator expectations;

LPC is a level of personality claims;

LNEc is a level of the navigator's expectations;

LAEc is a level of awareness of expected events;

LEAc is a level of expected attitude towards the participants of interpersonal inter-action;

LERc is a level of expected results of activity;

SPSS is a Statistical Package for the Social Sciences;

rpm_port is a vessel speed.

NOMENCLATURE

s is a motivational influencing factor;

S is a set of factors;

y is a control actions;

Y is a set of control actions;

x is a navigational situations;

X is a set of navigation situations;

w_{nav}^{a} is a navigator action utility function;

R is a navigation results space;

y'_{nav} is a navigator behavior alternatives;

$w_{nav\max}^{a}$ is a maximum expected usefulness for the navigator;

x_t is a moment of making decisions;

$Gv\uparrow$ is an expansion of feature space;

$Gv\downarrow$ is a narrowing of feature space;

Re is a peer review function;

K is a context of the navigation situation;

δ is a structural diagnostics;

DOI 10.15588/1607-3274-2021-3-13

$\underline{\delta}$ is a functional diagnostics;
e_r is a stock of resources for decision making;
Fr is a fragment to define MMS;
I is an information structure of the MMS identification task;
$\beta_0(S)$ is a prior distribution on the set of states;
$q^{u,\gamma}$ is a structure transition function;
φ_n is a safe vessel handling strategy;
π_1^n is a decision making strategy;
τ_1^n is a strategy for choosing alternatives;
ς_i is an alternatives of states;
x' is a comparison x with MMS;
R^S is a state space;
θ_n is a navigation risk criterion;
R_b is a binary relation;
$\Gamma(x_p)$ is a preference function;
Ω is a set matrix;
s_p is a complexity of the project;
u_q is an utility function;
af is an expectation level;
f is a subjective probability;
μ is a selective probability;
x_{ex} is an expenses;
v is a scaling factor;
γ is a reference level;
$\Delta(f)$ is a decision checkpoint function;
$P^*(s_p)$ is a probability measure;
X_H is a better alternative;
$\Im(x_{ex})$ are maximum values of the quality criterion relative to the strategy x_{ex};
$\Im_{opt}$ is an optimal solution;
Ω_X is an area of agreement and compromise;
Λ is an importance of criteria;
$P_{U_{x_i}}$ is a probability of the expected utility of a solution;
$P_{\left(C_{x_i} \geq U_{x_i}\right)}$ is a probability of the decision being useful is greater than initially expected;
ψ_t is an element of random behavior;
a^3, b^2, c^6 are words of the mathematical system;
G_1, G_2 are represent a group, for MMS;
G' is a producing a new group;
e_i is a starting point of the motivation identification system report;
g_1, g_2 are points of the Cayley's graph;
df are degrees of freedom;
Pr(>F) is a probability distribution;
Z is a decision-making task by the navigator;
$Z^{in}(t)$ is an inner emotional experience;
$Z^{ex}(t)$ is an external reactions, behavior model;
$E(t)<\infty$ is a shortage of time resources;
t_z is a discrete variable step;
Z_{Plan} is a how many tasks to be solved;
$\bigcirc$ is a future tense symbol;
D_Z is a how many targets to be deleted;
A_Z is a lots of added goals;
K_Z is a bounded rationality ratio;
Δ_Z is a bifurcation period of the motivation model;
Fun is an input processing method;
$M_{F_1 \ldots F_7}$ is a navigator motivation factor.

INTRODUCTION

Contemporary experimental data analysis systems has the tendency of welcoming the structural submission of human factor essence being predominantly characterized as a multifactorial phenomenon [1–3], which is empirically studied in various ergatic systems [4–6]. Being aware of having a diverse range of publications aimed at building and shaping the structure of this phenomenon we are to take into consideration possible uncertainties in the system of concepts as well as in their conceptual connections. This negative experience seemed to allow the implementation of the effective application of the spoken above techniques to be undertaken in practice of vessel control. However, the increasing number of navigation devices of ECDIS, ARPA, AIS, GPS and information brings new requirements to this problem [7–9]. It goes without saying that this very issue would definitely be considered advantageous enough in identifying the seagoing navigator's motivational mental state [10–12].

For example, when performing typical maneuvers of entering the harbor of Istanbul, it was noted that navigators are guided by different motives in the same navigation situations (Fig. 1).

Figure 1 – Control of electronic navigation when performing navigation maneuvers

All this indicates the need to build mathematical and automated systems for identifying the element of human factor – the motivation of navigators in order to improve the safety of navigation.

Thus, the **object of research** is the human-machine interaction of the ergatic system subject for water transport.

DOI 10.15588/1607-3274-2021-3-13

The **subject of research** is the models and algorithms for automated identification of navigator's motivation factor in the vessel electronic control systems.

The purpose **of research** is to apply formal and algorithmic approaches to extracting data on the motivational model of navigator to prevent accidents in water transport.

The purpose of the article is chosen to be applying special purpose solution method embracing of following problems:

1. Analyze the existing formal approaches in order to describe the principles of decision-making by navigators. And also to determine the elements of motivational models of decision-making by navigators in human-machine systems.

2. To propose the principle of extracting data on motivation of navigator in process of vessel control based on the geometric theory of groups in the form of $G' = G_1 \circ G_2$.

3. To form a 3D information model of the navigators structural motivation of based on Cayley's graph elements: $Cay\left\langle b \mid b^2 = e \right\rangle$, $Cay\left\langle a \mid a^3 = e \right\rangle$, $Cay\left\langle c \mid c^6 = e \right\rangle$.

4. Based on the data electronic simulator, correlate the characteristic spaces of MMS navigator motivation: LNE, LPC, LNEc, LAEc, LEAc, LERc and the vessel control parameters.

5. Conduct an experiment using the navigation simulator Transas navigation simulator NTPRO 5000. Based on the data obtained and Ward's dendrogram and MMS motivation points, using a number of statistical ANOVA methods in RStudio, build a motivation map of navigators.

6. On the basis of experimental data, determine the correspondence of motivational decision-making models F1–F7 regarding the navigators teams.

The obtained motivational models will make it possible to identify the class of decision-making by navigators in difficult situations to ensure the safety of water transport control.

1 PROBLEM STATEMENT

The formal statement of the problem is to identify the motivation of the navigator by analyzing the tuple of input variables, $s \in S$, $y \in Y$, $x \in X$ to $|X| \le |S|$ such that, $w^{\varsigma}_{nav} : \left(Y \times S \times X\right) \to R$ in terms of situational control [13, 14].

An additional condition for identification is maximization $w^{\varsigma}_{nav\max} : \left(x^*, y^*\right)_{s_t} \in X \times Y$ within the framework such that $y' \succ y \Leftrightarrow w^{\varsigma}_{nav\max}\left(y', s, x\right) > w^{\varsigma}_{nav}\left(y, s, x\right)$.

Identification is limited by terminal factors $\left(x_t \mid w^{\varsigma}_{nav\max}\right)$:

$$\forall x_t \operatorname{Re}\left(x_t \mid K\right) = \left(x_t \to \delta, \underline{\delta} \mid K\right) \to$$

$$\operatorname{Re}\left(\underline{\delta}\right) = e\left(Gv \uparrow \left(\underline{\delta}\right)\right) \otimes_e e\left(Fr\left(Gv \downarrow \left(\underline{\delta}\right)\right)\right).$$

in conditions:

$$I = \left\{S, \beta_0\left(S\right), X, \left[X_s \subset X, s \in S\right], Y, \left[Y_x \subseteq Y, x \in X\right],\right.$$
$$\left. A, q^{\varsigma}\left(S \mid S \times Y\right), w^{\varsigma}_{nav}\left(Y \times \left(S \times X\right)\right), \varsigma \in A\right\}.$$

The output variable is a $q^{\varsigma,\underline{\delta}}\left(S \mid S \times Y\right)_M$ and depends on M and $Con\left(x, x' \mid K\right) = 1 \Leftrightarrow x = x' : X_s \subset X,\ Y_x \subseteq Y$.

The main criterion of the task is a $\theta_n\left(\underline{\delta}^n_1 \mid \pi^n_1, \tau^n_1\right)$ in the space R^S, which will determine the dependence w^{ς}_{nav} on θ_n within the MMS scale.

The resulting factor is the navigation safety strategy $\varphi_n\left(\pi^n_1 \mid \tau^n_1\right)_{\underline{\delta}} \to \max$, in the form of a scale: $\underline{\delta}^{-1}\left(x\right)_M = \bigcup\left\{s \in S : \underline{\delta}\left(s\right) = x\right\} \subset S,\ x \in X$.

2 LITERATURE REVIEW

In a study aimed at modeling decision-making processes under the constraints of experiments [20], an approach based on use of R_b is proposed. Moreover, $\Gamma(x_{ex})$, determines the most preferable solutions from Ω. This study is of interest due to fact that, according the analogy with vessel control processes and the experimenter operates with a set of observed factors and criteria, such as in Fig. 2.

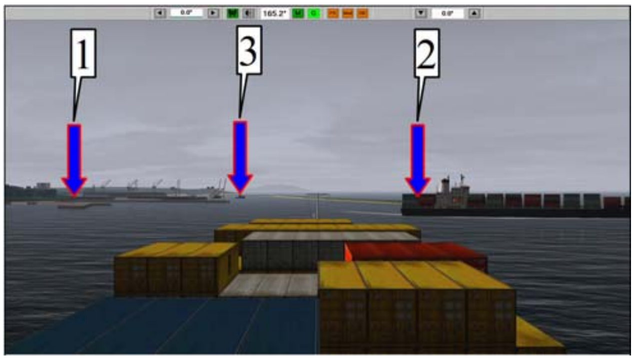


Figure 2 – Observed situation to vessel control

In the study [21], the processes of creating software based on recursion of data in the form of decisions made results are well considered. An important element is to take into account the risks associated with both stochastic uncertainty and s_i. In this case, it is important to accurately determine the factors determining u_q.

Also in the study [22], the solution to problem of decision-making synthesis models under conditions of fractal dimension is deeply and in detail considered. This study directs the scientific search for this article in field of logical-metric spaces, which allows us to consider the problem from a new angle. The paper considers methods for constructing feature spaces, as well as the principles of decision trees application in a practical aspect.

In turn, work [23] considers the aspect of taking into account subjective expectations when making decisions,

DOI 10.15588/1607-3274-2021-3-13

which is inapplicable in water transport management due to the high risk of disasters.

$$a_f = v^{-1}\left(Ev\left(f\right)\right),$$
$$U\left(f,\mu\right) = v\left(a_f\right) + \sum_{x\in\sup(\mu)} u\left(x_{ex} - \gamma a_f\right)\mu\left(x\right).$$

However, it should be borne in mind that captains are subject to decision-making based on the expected utility factor, which also depends on the individual motivational model. This is how the work introduces $\Delta\left(f\right)$ and $P*\left(s_p\right)$, which in our case predetermines the dependence on motivational factor:

$$U\left(f,\mu\right) = \sum_{s\in\sup(P*)} v\left(f\left(s_p\right)\right)P*\left(s_p\right) +$$
$$+\sum_{x\in\sup(\mu)} u\left(x_{ex} - \Delta\left(f\right)\right)\mu\left(x_{ex}\right).$$

It follows from this that an automated analysis of the captain's motivational factor can have a decisive impact on vessel control.

In the study [24], for decision-making, alternatives are considered that are decisive according to the introduced criteria:

$$X_H = \arg\max \Im\left(x_{ex}\right).$$

In this case, the optimality of decision taken is reduced to solving the chain of local goals, which forms the current strategy:

$$\Im_{opt} = \Im\left(X_{opt}\right) = \underset{X\in\Omega_X}{opt}\left[\Im\left(X\right),\Lambda\right].$$

However, in the case of performing navigation tasks and vessel control tasks, this approach may not be effective enough. This is due to the fact that, guided by motivational model, the captain can no longer change of strategy and follows predetermined principles until the last stage of the task.

In this work, the human factor is determined randomly [25]. In this case, a distinction is indicated according to the degree of random factors influence:

if $P_{U_{x_i}} \geq P_{\left(C_{x_i}\geq U_{x_i}\right)}$

then $0 \leq \psi_t \leq 1 - \left(P_{U_{x_i}} - P_{\left(C_{x_i}\geq U_{x_i}\right)}\right)$

or if $P_{U_{x_i}} < P_{\left(C_{x_i}\geq U_{x_i}\right)}$

then $\left|P_{U_{x_i}} - P_{\left(C_{x_i}\geq U_{x_i}\right)}\right| \leq \psi_t \leq 1 + \left|P_{U_{x_i}} - P_{\left(C_{x_i}\geq U_{x_i}\right)}\right|.$

However, in transport systems, random processes are unlikely. Marine companies try to take into account random factors in order to reduce the likelihood of unforeseen accidents and disasters.

Thus, the studies considered indicate the need for a scientific search for approaches to formalize and algorithmize the factors of motivating navigators when managing water transport.

3 MATERIALS AND METHODS

During the work with navigational devices, the records of the navigators' activity are saved on the server. The information received indicates the nature and settings of the vessel control model in the ergatic system.

Devices such as information navigation systems, radar and warning systems are synchronized. Their use cannot be simultaneous; therefore, it becomes possible to identify the motivation of the navigators.

To meet the above mentioned targets, an unambiguous approach is proposed to be implemented consisting of two essential stages: the first one is defining the navigator's motivational centers and their significance within the framework of the visual geometric concept and the second one is an analysis of decision making by navigators to determine their MMS.

Consider the stage of determining the navigator's motivational centers. We will establish the order of identifying extrema of the navigators' motivation. We will assume that these extrema were revealed in the course of observation and a series of specialized tests [15–17]. In order to measure their influence, it is necessary to analyze a number of indexes of MMS selectively using the methodology of social expectations of personality.

Application of psycho-diagnostic instruments for examining an individual's motivation. We will consider two methods as instruments for determining the influence of extrema: "LNE", modified and "LPC" that have correlations investigated in the study, and therefore they must be presented within the same metric space [18,19].

Having determined the extrema of MMS, we will choose the outlined methods relative to them. Each of them will – G_1 and – G_2. Simultaneous participation of the methods will be presented as a product of these groups, producing a G' [26].

Since there are: a^3, b^2 and c^6 in the group $G' = G_1 \circ G_2$ and each one is a geometric structure, we have Cayley's graphs for all of them (Fig. 3):

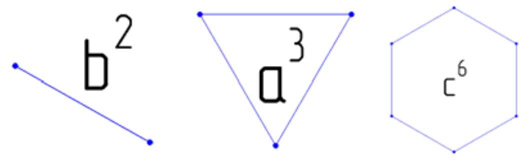
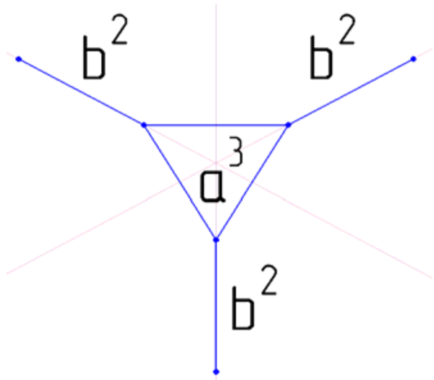


Figure 3 – The words: a^3, b^2 and c^6 in the group

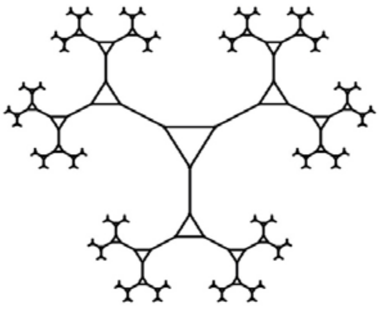
DOI 10.15588/1607-3274-2021-3-13

Then group $G' = G_1 \circ G_2 = \langle a,b,c \mid a^3 = b^2 = c^6 = e \rangle$, meaning that Cayley's graph of a free product implies "agglutination" of two graphs G_1 and G_2.

In order to create Cayley's graph of the group G_1 we proceed from the following logic: G_1 has two generatrixes, i. e. The number of edges equals to a doubled product of the generatrixes – 4, but as far as b^2 is a biangle and "agglutinates" in one section, we have three edges – sections. Therefore, we put one edge b^2 (in sum – three) from each point of the apex (of the triangle) a^3 and have Cayley's graph for G_1 (see Fig. 4 a, b).



a

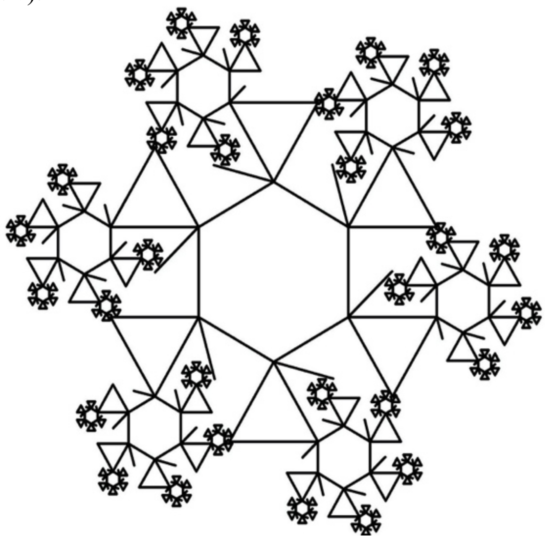


b

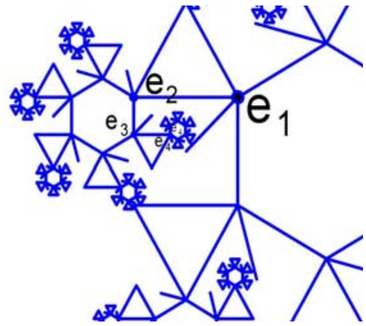
Figure 4 – The formation of Cayley's graph for G_1:
a – composition of generators for G_1; b – fractal of Cayley's graph representation

The move to the stage of the formation of the group G'. In order to obtain a product, we multiply G_1 by G_2, represented by a hexahedron and we will determine the number of edges of the graph. Proceeding from the fact that there are three products, we will double and get 6, but there will be 5 because of "agglutination" b^2. Consequently, the products $G' = G_1 \circ G_2$ will have Cayley's graph depicted in Fig. 5.

Each point e_i, synchronizes with the point – extrema of MMS and allows identifying their influence. The graph G' allows examining each extremum of MMS in a combinative way. We can see that e_1 originates from the application of the "motivational core" c^6, then there is a move to the method "LNE", and the first step is to perform analysis of the index LNEc. Further, if the order of the methods proves to be not efficient enough, then the next round of the research starts from the point e^2, beginning with "LNE", without LNEc and further moves to the "motivational core" c^6, and then to LNEc. This group can be represented in a 3D projection for visualization (see Fig. 6).



a



b

Figure 5 – Cayley's graph of the desired group G':
a – fractal space of $G' = G_1 \circ G_2$; b – representation of extremum points on a Cayley's graph space

.

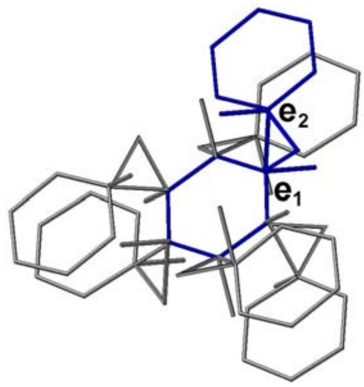


Figure 6 – 3D view of the group G'

The next task is to identify the influence of the extrema of motivation, determining the importance of the event projected onto a newly created group of the manifestation of MMS. The determination of the indexes relative to the extrema of motivation by the chosen methods implies the

DOI 10.15588/1607-3274-2021-3-13

use of a comprehensive approach [27–29]. Taking into account that the methods number 10 indexes and they correlate with each other to this or that extent that was proved by the research, we can maintain that they are indissoluble. Consequently, it is necessary to find the generalized value of the extremum of motivation summarizing the data of all the indexes. Therefore, we developed a program module that allows synchronizing the data in one Cartesian coordinate system C_i (see Fig. 7). For instance, there is the above-mentioned trajectory b^2ab, followed by the strategy b^{-1} "planning to move a rudder blade", that is evident in the pause in the vessel route and a radical change in the course.

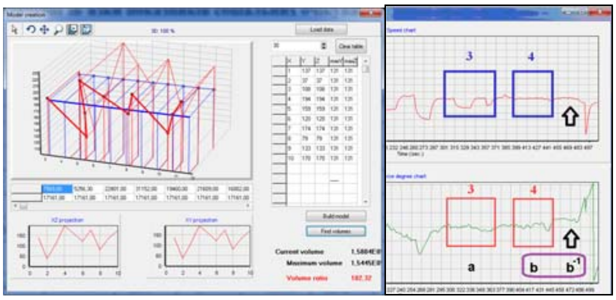


Figure 7 – Determining the influence of the points C_i of MMS

Having obtained the data of all the indexes we can use this module to find the generalized index of the navigator's motivation. Following the trajectory of examining the points of MMS and determining the most effective approach we select an individual algorithm of interaction with each navigator within the framework of the research of his motivation. The accurate values of the points of MMS enable us to understand that the surface circumflexing them cannot be flat and it results in the curvature of the metric space of motivation. This curvature of the surface is nothing but an individual and unique imprint of the navigator's perception of the situation in the light of his motivation [30–32].

In this way a quasi-isometric formal surface with the points of extremum is formed [33, 34]. The question arises: what correlation is between them and can they play the role of a connected graph? It is known that these lines are geodesic, i. e. the surface itself is not curvilinear. This research stage requires the application of the method making it possible to find these connections between the points-extrema. The connection between the points by the edge is only possible when the subsequent point emerges from the preceding one when multiplied by one letter of the set of the generatrixes. For instance, g_1 and g_2 are connected by the edge if $\exists a \in A; g_2 = g_1 \cdot a$ or $g_1 = g_2 \cdot a$ in the set of generatrixes.

It is important to find the principle of transfer, connecting these points by the edges, something common and essentially important within the framework of the methodology of social expectations of an individual. Grouping points-extrema of motivation is necessary to determine MMS, and, consequently, to achieve the main purpose of the research.

The analysis of the points-extrema gives us a reason to think that these points are heterogeneous, each of them having a number of parameters consisting of three categories: identifiers relative to Cayley's graph; psychological methods "LNE" and "LPC"; factors relative to sailing through the Bosporus strait.

4 EXPERIMENTS

Taking into consideration the specificity of the subject area and also the geometric orientation of the scientific research, we suggest clustering the data. Cluster analysis will allow dividing the points of motivation MMS into groups and determining their relationships geometrically.

In order to do this, we used clustering in the form of a dendrogram by Ward's method for finding single connections of the points of MMS, by the principle of Euclidian distance (see Fig. 8). Having analyzed these geometric connections between the points of motivation of MMS, we are enabled to construct the desired map of the navigator's motivation (see Fig. 9).

The represented geometric relationships of MMS allow visualizing how the manifestations of the navigators' motivation are ordered in the desired conditions. It is necessary to mention that this order is characteristic only of a certain individual and determined by a variety of factors, affecting their motivation. It allows predicting navigators' behavior in critical situations similar by the set of indexes that will make it possible to prevent disastrous situations on maritime transport. Hence, according to the involved approach, the relationship, the personality structure of some navigators' motivation being actively engaged in complex maneuver operations is highly likely to be ascertained [35–37].

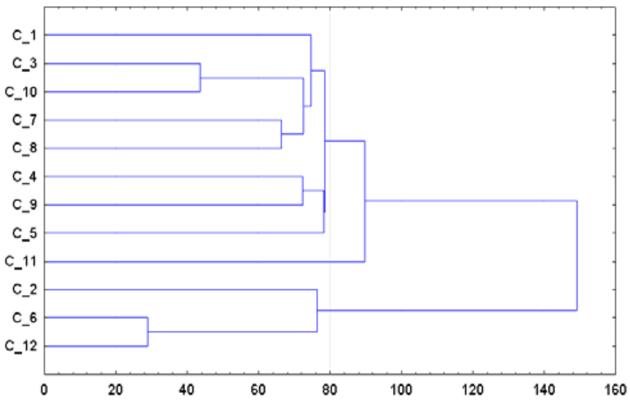


Figure 8 – The dendrogram by Ward's method for the points of motivation of MMS

It must be emphasised that the foremost phase of this research is being able to figure out the method facing the challenge of having clusters of navigation situations according to the indications of navigators' actions for correlating them with their motivational mental states.

DOI 10.15588/1607-3274-2021-3-13

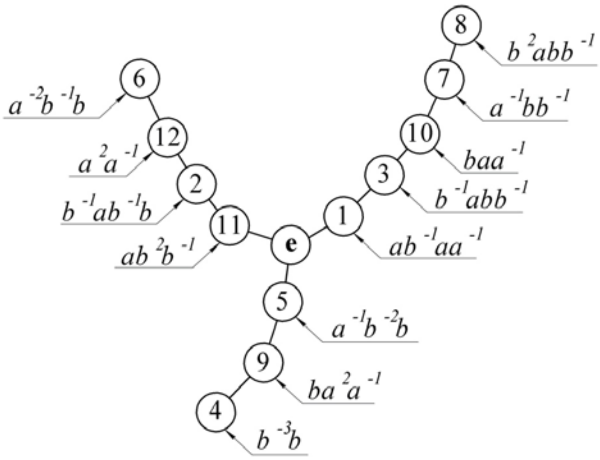


Figure 9 – The map of the navigator's motivation

It should be underlined separately that we propose the concept; "he navigator's mental motivational state" to be applied as "the general functional level of mental activity having direct impact on the conditions of his professional activity and individual psychological characteristics". In the course of the research situational mental states connected with the definite location in the water area and navigation tasks at the corresponding time interval are put forward to be taken into consideration.

Being on the point of getting a passing, especially within the high intensity maritime transport areas, the navigator of the vessel is striving to endeavor to accomplish the navigation task in the best possible light. Therewith, the significant element of such kind of work is noticed to be the skill of the navigator's motivational sphere management, knowledge of the structure and system of meaningful characteristics of motivational mental states. In addition, such properties as internality, externality, activity, passivity, openness, closeness, etc. are being able to facilitate this or that MMS discovery with sufficient accuracy. Thus, having been spoken about approaches would definitely further encourage us to come closer to the definition of characteristics welcoming the direct effect on the result of professional activity as well as to the relevant to the having been formed individual behavior patterns to be taken on.

The sequential search performed among test methods at the preliminary stage is noticed to have triggered off the opportunities to determine the individual prerequisites for the manifestation of motivational characteristics. Accordingly, hese very issues indicate at MMS and an established behavior model. Thus, the following possibilities to be determined have turned out : an internal motive, a cognitive motive, a avoidance motive, a competition motive, a motive for a change in activity, a self-esteem motive, significance of results, complexity of the task, volitional effort, assessment of the level of achieved results, assessment of one's potential, target level of mobilization of efforts, expected level of results, regularity of results and initiative.

In response to the mentioned above, the methods based on coping tests [38, 39] let eight ways of difficulties overcomings be lighted upon. These items probably include the following to be worth mentioning: confrontation, distancing, self-control, seeking social support, taking responsibility, avoidance, planning a solution to the problem, positive revaluation. The fractal organization of the above methods at key stages of the route trajectory conduce to delineate the correlation of the dominant motives to the situations.

It must be emphasised that the foregoing happened to have provided the possibility to significantly reduce the time for MMS analysis being predominantly concentrated on the likelihood of "bursts" of navigators' motivational activity. So, this approach is said to have hastened the selection of the required methodology basing on three or four stages of navigators' actions in typical situations.

Taking into account the evidence of vivid manifestation of navigators' mental activity boost getting used to being accompanied by an increase in their motivation the conclusion is that the nature of the actions precisely indicates the navigators' mental state.

Well, for instance, such a parameter as rpm_port at moderate rates (3–5 knots) is unable to be affecting the mental activity boost but, nevertheless, at high rates (8–12 knots) makes the navigators severely enhance their entire capacity-building. It goes without saying that this item is impossible to be looked at without motivation [40].

With an aim to analyze the influence of this parameter on the MMS shaping we want a range diagram (Boxplot) rpm_port (main rotor speed) to be introduced. For getting analysis done an experiment was carried out with 11 different navigation teams being involved in facing the same terms and conditions of the Bosphorus location. So, from the analysis of the diagram the sample differences are sure to be noticed. The medians are not noticed to be significantly different only in the first, second and third samples (rpm_port1, rpm_port2, rpm_port3). Sample data rpm_port1, rpm_port6, rpm_port7, rpm_port8, rpm_port9, rpm_port10 skewed to the left; rpm_port10, rpm_port11 – skewed to the right; rpm_port5 – symmetric; rpm_port2, rpm_port3 – very tight placement (Fig. 10).

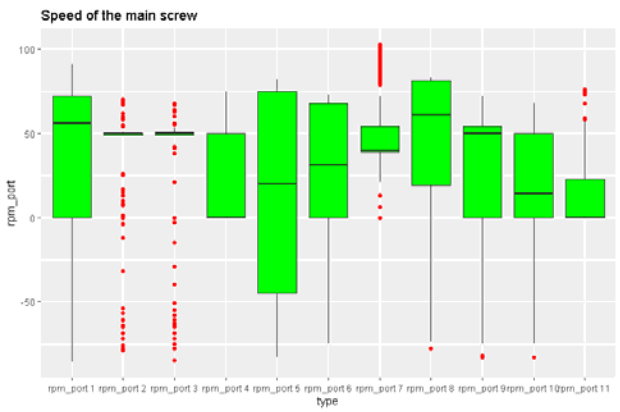


Figure 10 – Boxplot plot of the rpm_port parameter

The interquartile range does not visually differ too much in the samples rpm_port4, rpm_port6, rpm_port8, rpm_port9, rpm_port10. The samples rpm_port2, rpm_port3, rpm_port7 have a lot of outliers.

DOI 10.15588/1607-3274-2021-3-13

So, having been delivered results do indicate a clear difference in the navigators' behavior models. For example, the rpm_port speed parameter and its change along the trajectory of the routes are presenting significant differences. In order to achieve the target of finding the groups having alike patterns of behavior a confidence interval diagram was decided to be navigator.

It would be highly appreciated due to reflecting the presence of common points of intervals for the following groups of samples: rpm_port1, rpm_port2, rpm_port7, rpm_port8; rpm_port1, rpm_port3, rpm_port9; rpm_port3, rpm_port6, rpm_port9; rpm_port4, rpm_port5, rpm_port6, rpm_port10, rpm_port11; rpm_port5, rpm_port6, rpm_port9, rpm_port10. Average items closely spaced for the following groups of samples: rpm_port1, rpm_port2; rpm_port1, rpm_port3; rpm_port2, rpm_port7, rpm_port8; rpm_port4, rpm_port5, rpm_port6, rpm_port10, rpm_port11; rpm_port6, rpm_port9, rpm_port10 (Fig. 11).

Subsequently, to determine the homogeneity of variances, the Bartlett Test of Homogeneity of Variances and Computes Levene's test for homogeneity of variance across groups centered on the median are considered to be of great assistance.

Bartlett test of homogeneity of variances
data: rpm_port by type
Bartlett's K-squared = 428.15, df = 10, p-value < 2.2e-16
Levene's Test for Homogeneity of Variance (center = median)
Df F value Pr(>F), group 10 39.493 < 2.2e-16 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

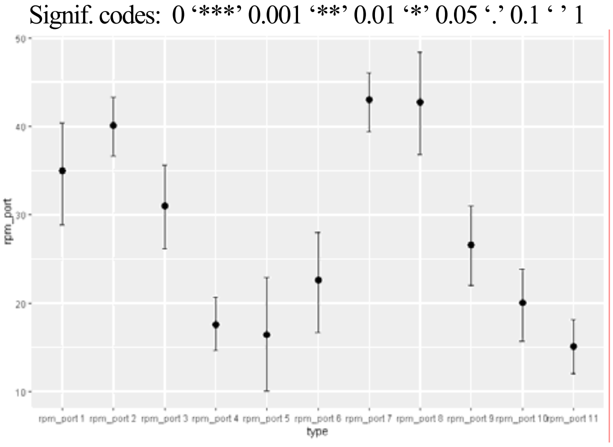


Figure 11 – Diagram of confidence intervals for the rpm_port

Accordingly, based on the results of both completed tests, we are definitely to discard the null hypothesis of equality of variances (since with F10,2992 = 39.493 p-value < .05). This issue indicates the evidence of variances to be different being admitted as solid proof that the populations from which the data is selected are not to be regarded as identical. Further, we are on the point of performing ANOVA aiming to compare the average samples. As a result, the number F10,2992=20.23, p<2e-16. was obtained. The conclusion can be made, this issue means that there are statistically significant differences between the average samples of the rpm_port parameter. This item is believed to be the ground to have the hypothesis of the study of shaping navigator's behavior models with individual characteristics generally confirmed. Further, let's do posteriori comparisons with an aim to identify differences between the samples. As the test for equality of variances is noticed to have uncovered statistically substantial differences, the Games-Howell one being used for pairwise comparison of normally distributed samples with unequal variances is proposed to be introduced. The obtained results are presented in Table 1.

It is vividly seen that after having carried out analysis of the table five types of navigators' behavior models are highly likely to be identified.

Therefore, each of these issues represents the maximum number of samples between having no statistically significant differences [41–43]. To be precisely, no differences were able to have been observed in the middle of each behavior model.

Moreover, at least one statistically significant difference between the behavior models do exist. Group1 includes: rpm_port1–8; group3: rpm_port1, rpm_port3–9; group4: rpm_port4–6, rpm_port10–11; group5: rpm_port5, rpm_port6, rpm_port9, rpm_port10 (Fig. 12 a, b).

Hence, the analysis of the diagrams as well as the application of subsequent techniques delivered a beneficial opportunity for us to succeed in having the navigational watches grouped. No. 1–11 (Fig. 12 b).

Table 1 – The difference is a statistically significant difference between the sample

	rpm_port1	rpm_port2	rpm_port3	rpm_port4	rpm_port5	rpm_port6	rpm_port7	rpm_port8	rpm_port9	rpm_port10
rpm_port2	–									
rpm_port3	–	–								
rpm_port4	differ	differ	differ							
rpm_port5	differ	differ	differ	–						
rpm_port6	–	differ	–	–	–					
rpm_port7	–	–	differ	differ	differ	differ				
rpm_port8	–	–	–	differ	differ	differ	–			
rpm_port9	–	differ	–	differ	–	–	differ	differ		
rpm_port10	differ	differ	differ	–	–	–	differ	differ	–	
rpm_port11	differ	differ	differ	–	–	–	differ	differ	differ	–

DOI 10.15588/1607-3274-2021-3-13

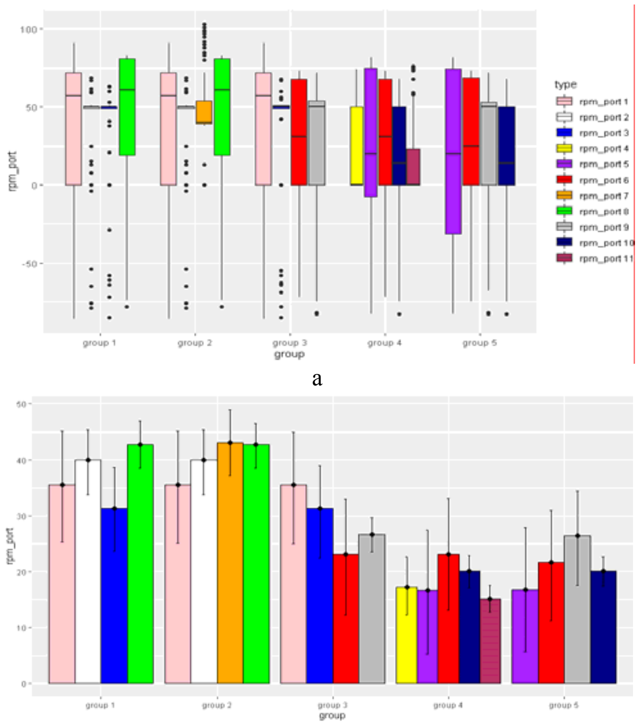


Figure 12 – Diagram of the groups of statistically significant difference between the behavior models: a – boxplot diagram of the groups of samples of the rpm_port parameter between which statistically significant differences were revealed; b – diagram of confidence intervals for the groups of samples of the rpm_port parameter between which statistically significant differences were revealed

Besides, the having been developed questionnaires contributed into process of getting empirical data obtained for each formed group.

Data processing with RStudio and "SPSS" v. 23.0 turned out to be favorable enough to apply to Spearman's statistical correlation methods, the Promax component rotation one and etc. So, to calculate the minimum, maximum, arithmetic mean of the parameters and standard deviations became highly likely to be done.

5 RESULTS

The calculated results were a huge assistance of allowing us to correlate the survey data and the navigators' mental motivational states (Table 2).

Thus, the conclusion can be made that the having been proposed approach assumes indirect navigators' MMS determination by means of the parameters of the vessel's movement. Then, with respect to the level of goal-setting, we define the model of the motivational factor influence on the water transport operation:

$$Z(t_z+1)=Z(t_z)\setminus D_Z(t_z+1)\cup A_Z(t_z+1) \text{ if } 0<\mathrm{E}(t)<\infty,$$
$$\forall t\ Z(t)=Z^{in}(t)\cup Z^{ex}(t),$$
$$D_Z(t_z+1)\ \&\ A_Z(t_z+1)=\arg opt_{Z(t)}K_Z(t_z+1),$$
$$Z_{Plan}(t_z+\bigcirc)=Z_{Plan}(t_z+\bigcirc)\cup\{Z-task\}_t,$$
$$\uparrow Z(t_z)=\left[Z(t_z)\to Chaos(t_z+1-\Delta_z,\Delta_z)\right],\ \Delta_z\to \min,$$
$$E(t+1)=Fun\left(E(t),Z(t),\{F(t)\},M_{F_1\ldots F_7}(t)\right).$$

Moreover, despite being a success, this approach is to be taken only at the initial stages of psychological diagnostics [44]. Much further analysis of likewise conclusions is sure to presume the involvement of a highly qualified specialist. This will allow the development of an intelligent assessment of diagnostics of experimental data in real time [45].

Table 2 – Mental motivational states of navigators

Commands	Mental motivational states of cadets
2, 8, 7	F3 "Motivation for obtaining" is considered to be a reflection of significant motivation levels to compete and motivation to succeed without having positive reassessment of the real situation. The motivational *mental state* of this group of cadets is having a lot to do with craving to achieve the desired result at any cost. F6 "Affiliation motivation" is said to be characterized as the desire of the individual to be better than others. The subject is being implicated into constant retrieval to perform complex tasks of professional activity seeking social support and encouragement in the environment sometimes in the eyes of beholder close friends.
1, 3	F2 "Confrontational motivation" is the individual's confrontational regulatory ability to do something by his own initiative, to confront avoiding the search of other alternatives to cope with the problem as well as shirking the responsibility and positive reassessment of the situation. F4 "Pragmatic motivation" is said to be planning for solving a problem with having it not accompanied by a positive reassessment of the real situation. This motivational *mental state* needs to be defined mostly as the search for approval, a desire to hold on to one's point of view and beliefs.
9, 6	F1 "Ego-motivation" is said to reflect the dependence of the individual components of the personality's motivational structure, to be directly, internal and cognitive motive, volitional effort, assessment of one's potential, the intended level of efforts mobilization. The significant negative correlation with confrontation and self-control in the context of professional activity performing is definitely to be taken into consideration. The effect of this factor seems to be characterized by internal and cognitive activity in professional activity. F7 "Motivation for responsibility" depicts the idea of getting all motivational mental states accompanied by the desire to perform all assigned tasks from the simplest to the most difficult ones appropriately. Such a motivational *mental state* is being thought about as inherited peculiarity for being prone towards order, and discipline in everything.
4, 5, 10, 11	F5 "Motivation for avoidance" includes variables, the psychological content of which is aimed at mirroring the desire to escape from responsibility, initiative and whatever. It seems to have a negatively evaluated significant relationship with the assessment of the level of achieved results. Such individuals have a tendency to totally circumvent no way having to deal with anything. They get used to being apt to "keep your head down".

DOI 10.15588/1607-3274-2021-3-13

Hence, the proposed approaches are believed to have been implemented and tested in the course of an experiment using the Navi Trainer 5000 navigation simulator. They managed to have demonstrated the potential and the effectiveness of the proposed above research hypotheses. The experimental data, as well as the developed psychological methods for analyzing sea-going navigators' mental motivational states while performing complex maneuvers and navigation tasks, facilitate to find out important dependencies and come up as a result of scientific research.

As a result of the study, the expediency of the psychological and informational approaches used, as well as the principles of the formation of models of behavior of navigators in difficult conditions was confirmed.

Thereby, the psychological and formal-analytical approaches presented in the study, as well as the developed software tools, are named to be worth being delivered to apply the classification of the navigators' mental motivational states in the form of a geometrically defined space of states. Accordingly, the results of the study might be of great interest and assistance for the sake of predicting and preventing catastrophic consequences in maritime transport due to the human factor.

CONCLUSIONS

We analyzed formal approaches to the practical aspects of the decision theory application in situations of stochastic uncertainty and resource constraints. As a result, an approach was proposed that is closest to the problem of research based on the models formation of motivation when making decisions by navigators in human-machine systems.

On the basis of the indicated approach, the principle of vessel controlconverting information parameters from the ECDIS server was determined. This made it possible to structure the data on the motivation the navigator on the basis of geometric product of groups $G' = G_1 \circ G_2$.

A 3D information model the structural motivation of navigators was formed based on the Cayley's graph elements: a^3, b^2, c^6. This made it possible to identify the extremum points of motivation, to determine the degree of importance in relation to MMS.

On the basis of electronic simulator data the periods of extrema were synchronized with respect to the speed-power parameters of the vessel's control. This made it possible to form the characteristic spaces of motivation the MMS navigator: LNE, LPC, LNEc, LAEc, LEAc, LERc.

To achieve the main goal of the study, an experiment was carried out, as a result of which data were collected on the motivational models of navigators when performing a maneuver of entering the harbor of Istanbul. The data were obtained in the course of automated analysis of NTPRO 5000 navigation simulator log files with subsequent processing by statistical ANOVA methods in RStudio. As a result of calculations, a motivation map for navigators was built based on Ward's dendrogram and MMS points.

On the basis of experimental data, motivational models of decision-making F1–F7 of navigators teams were determined.

The obtained motivational models will make it possible to identify the class of decision-making by navigators in difficult situations to ensure the safety of water transport control.

Thus, this study made it possible to significantly approach the solution of the problems to identifying motivational models of water transport navigators to ensure safety.

ACKNOWLEDGEMENTS

The team of authors is grateful to the management of the Kherson State Maritime Academy (Ukraine) for the opportunity to conduct research on the basis of the research laboratory "Development of decision support systems, ergatic and automated vessel control systems" using the certified Navi Trainer 5000 navigation simulator. The study was carried out within the framework of the research topic No. 0121U109680 "Development of latest models and software for automated control systems for civil and special-purpose marine vessels".

REFERENCES

1. Yundong H. Work notivation and operational risk assessment. A new direction for organizational behavior studies, SSRN, 2016, *Electronic Journal*. DOI: 10.2139/ssrn.2758698.
2. Edwards T., Poling, A. (2020). Motivating operations and negative reinforcement. *Perspectives on behavior science*, 2020, Vol. 4, No. 43, pp. 761–778. DOI:10.1007/s40614-020-00266-8.
3. Ahmad M. A. A., Bakry H. El., Mohamed A. E. D. et al. The impact of using virtual reality on student's motivation for operating system course learning, *Journal of E-Learning and Knowledge Society*, 2020, Vol. 2, No. 16, pp. 25–33. DOI:10.20368/1971-8829/1135076.
4. Nosov P. S., Ben A. P., Mateichuk V. N. et al. Identification of "Human error" negative manifestation in maritime transport, *Radio Electronics, Computer Science, Control*, 2018, Vol. 4, No. 47, pp. 204–213. DOI:10.15588/1607-3274-2018-4-20.
5. Nosov P., Ben A., Safonova A. et al. Approaches going to determination periods of the human factor of navigators during supernumerary situations, *Radio Electronics, Computer Science, Control*, 2019, Vol. 2, No. 49, 140–150. DOI:10.15588/1607-3274-2019-2-15.
6. Nosov P. S., Zinchenko S. M., Popovych I. S. et al. Diagnostic system of perception of navigation danger when implementation complicated maneuvers, *Radio Electronics, Computer Science, Control*, 2020, Vol. 1, pp. 146–161. DOI:10.15588/1607-3274-2020-1-15.
7. Zinchenko S. M., Ben A. P., Nosov P. S. et al. Improving the accuracy and reliability of automatic vessel moution control systems, *Radio Electronics, Computer Science, Control*, 2020, Vol. 2, pp. 183–195. DOI:10.15588/1607-3274-2020-2-19.

DOI 10.15588/1607-3274-2021-3-13

8. Frisson C., Malacria S., Bailly G. et al. A system to analyze users behaviors in their applications, *InspectorWidget*, 2016, pp. 1548–1554. DOI:10.1145/ 2851581.2892388.
9. Zinchenko S.M., Nosov P.S., Mateychuk V.M. et al. Automatic collision avoidance with multiple targets, including maneuvering ones, *Radio Electronics, Computer Science, Control*, 2019, Vol. 4, pp. 211–221. DOI: 10.15588/1607-3274-2019-4-20.
10. Shevchenko R., Popovych I., Spytska L. at al. Comparative analysis of emotional personality traits of the students of maritime science majors caused by long-time staying at sea, *Revista Inclusiones*, 2020, Vol. 7, num Especial, 538–554.
11. Shevchenko R., Cherniavskyi V., Zinchenko S. at al. Research of psychophysiological characteristics of response to stress situations by future sailors, *Revista Inclusiones*, 2020, Vol. 7, num Especial, 566–579.
12. Solmaz M., Özsever B., Güllü A. et al. Development of evaluation procedures for watchkeeping officers using bridge simulator, *TransNav, the International journal on marine navigation and safety of sea transportation*, 2020, Vol. 14, pp. 565–571. DOI:10.12716/1001.14.03.07.
13. Prokopchuk Y. A. Sketch of the Formal Theory of Creativity. Dnepr, PSACEA Press, 2017, 452 p.
14. Baranov V. V. Processes for making management decisions motivated by interests, Fizmatlit, 2005, 296.
15. Irodov V. F., Barsuk R. V. et al. Decision-making during limited of experiments with multiple criteria, *Radio Electronics, Computer Science, Control,* 2020, Vol. 1, pp. 200–208. https://doi.org/10.15588/1607-3274-2020-1-20.
16. Melnyk K. V., Hlushko V. N., Borysova, N. V. et al. Decision support technology for sprint planning, *Radio Electronics, Computer Science, Control*, 2020, Vol. 1, pp. 135–145. https://doi.org/10.15588/1607-3274-2020-1-14.
17. Subbotin S. A., Gofman Y. A. The fractal analysis of sample and decision tree model, *Radio Electronics, Computer Science, Control*, 2020, Vol. 1, pp. 98–107. https://doi.org/10.15588/1607-3274-2020-1-11.
18. He Ying, Dyer James, Butler John. A decision-making model with utility from anticipation and disappointment, *Journal of Multi-Criteria Decision Analysis*, 2019, Vol. 26. 10.1002/mcda.1657.
19. Lu, Jin-Biao, Liu, Zhi-Jiang, Tulenty, Dmitry et al. Implementation of Stochastic Analysis in Corporate Decision-Making Models, *Mathematics*, 2021, Vol. 9. DOI:10.3390/math9091041.
20. Acevedo Rafael, Fernández Pedro, Mora Jose et al. Rational Irrationality: A Two-Stage Decision-Making Model. *Advances in Decision Sciences*, 2021, Vol. 25. DOI:10.47654/v25y2021i1p1-39.
21. Pleskacz K., Uriasz J. Understanding of navigational information systems, *Annual of navigation*, 2012, 19, pp. 121–132. DOI:10.2478/v10367-012-0010-z.
22. Wenting L. Tian S., Hong Z. et al. Interface design in the ship navigation information system, *IEEE 11th International Conference on Computer-Aided Industrial Design & Conceptual Design,* 2010, Vol. 1, pp. 395–400. DOI:10.1109/CAIDCD.2010.5681326.
23. Wang C., Zhang J., Yu H., Wang D. et. al. Experimental study of optimized interface displays of navigation information system, *Lecture Notes in Electrical Engineering*, 2015, DOI:10.1007/978-3-662-48224-7_45.
24. Nosov P.S., Popovych I.S., Cherniavskyi V.V. et al. Automated identification of an operator anticipation on marine transport, *Radio Electronics, Computer Science, Control*, 2020, Vol. 3, pp. 158–172. DOI:10.15588/1607-3274-2020-3-15.
25. Stillwell J. Group Theory. *In book: Mathematics and Its History*, 2020, pp. 257–282. DOI:10.1007/978-3-030-55193-3_14.
26. Malyutin A., Netsvetaev N. Geometry and topology. Part 10, *Journal of Mathematical Sciences*, 2009, Vol. 3.
27. Huebner M., Vach W. Cessie le S. A systematic approach to initial data analysis is good research practice, *The journal of thoracic and cardiovascular surgery*, 2015, P. 151. DOI:10.1016/j.jtcvs.2015.09.085.
28. Clarke W. Approaches to data analysis, *Clinical trials in neurology, Design, Conduct, Analysis*, 2012, pp. 52–68. DOI:10.1017/CBO9781139032445.007.
29. Weir J.P. Statistical approaches to data analysis, *ACSM's Research Methods*, 2015, pp. 325–342.
30. Lehtola V., Montewka J., Salokannel J. Sea captains' views on automated ship route optimization in ice-covered waters, *Journal of Navigation*, 2019, Vol. 73, pp. 1–20. DOI: 10.1017/S0373463319000651.
31. Picu C., Rusu E. Multiple physical stress exposures of sailors on several ships – a longitudinal study, *Physics, Theoretical Mechanics*, 2018, Vol. 41. pp. 84–93. DOI:10.35219/ann-ugal-math-phys-mec.2018.1.12.
32. Slišković A., Penezic Z. Lifestyle factors in Croatian seafarers as relating to health and stress on board, *Work*, 2017, Vol. 56. pp. 1–10. DOI:10.3233/WOR-172501.
33. Degtyarev A., Itenberg I., Kharlamov V. Real surfaces: the topological aspects, *Lecture Notes in Mathematics book series*, 2000, Vol. 1746. DOI:10.1007/BFb0103965.
34. Gregori V., Miñana J., Miravet D. A duality relationship between fuzzy partial metrics and fuzzy quasi-metrics. *Mathematics*, 2020, Vol. 8, No 9, P. 1575. DOI:10.3390/math8091575.
35. Chaudhari M., Sarkar S., Sharma D. Analyzing risky behavior in traffic accidents, *Navigation and transport*, 2020, pp. 464–471. DOI:10.1109/ SMC42975.2020.9283330.
36. Smolarek L. Dimensioning the Navigational Safety in Maritime Transport, *Journal of Konbin*, 2010, Vol. 1415. pp. 271–280. DOI:10.2478/v10040-008-0184-6.
37. Kriukova T.L., Kuftiak Ye.V. The questionnaire of controlling (The Adaptation of the Methods WCQ), *Journal of an applied psychology specialist*, 2007, Vol. 3, No. 93. pp. 102–112.
38. Lazarus R. S., Folkman S. Stress, Appraisal and coping. New York, Springer Publishing Company, 1984, URL:https://www.worldcat.org/title/stress-appraisal-and-coping/oclc/609341596.
39. Quadri C., Zignani M., Gaito, S. et al. Gathering behavior of groups of people in a city. *IEEE International Conference on Smart Computing*, *SMARTCOM,* 2018, DOI:10.1109/SMARTCOMP.2018.00025.
40. Pazouki K., Zaman I., Norman R., et al. Development of automatic mode detection system by implementing the statistical analysis of ship data to monitor the performance, *The International Journal of Maritime Engineering*, 2017, Vol. 159, pp. 225. DOI:10.3940/ rina.ijme.2017.a3.411.
41. Guo B., Bitner-Gregersen E. M., Sun H. et al. Statistics analysis of ship response in extreme seas, *Ocean Engineering*, 2016, Vol. 119. DOI:10.1016/ j.oceaneng.2016.03.060.
42. Eliopoulou E., Papanikolaou A., Voulgarellis M. Statistical analysis of ship accidents and review of safety level, *Safety Science*, 2016, Vol. 85, pp. 282–292. DOI:10.1016/j.ssci.2016.02.001.

DOI 10.15588/1607-3274-2021-3-13

43. Nosov P. S., Cherniavskyi V. V., Zinchenko S. M. et al. Identification of marine emergency response of electronic navigation operator, *Radio Electronics, Computer Science,* Control, 2021, Vol. 1. pp. 208–223. DOI:10.15588/1607-3274-2021-1-20.
44. Pinakpani P., Polisetty A., Bhaskar G. at al. An Algorithmic Approach for Maritime Transportation, *International Journal of Advanced Computer Science and Applications*, 2020, P. 11. DOI:10.14569/ IJACSA.2020.0110296.
45. Bazaras D., Palšaitis R., Petraška A. et al. Criteria System of Emergency Situations Risks Assessment in the Baltic Sea Ports.*Transport and Telecommunication Journal*, 2017, Vol. 18. DOI:10.1515/ttj-2017-0024.

Received 14.06.2021.
Accepted 03.08. 2021.

УДК 004.942:656.61.052

АВТОМАТИЧНЕ ВИЗНАЧЕННЯ МОДЕЛІ МОТИВАЦІЇ НАВІГАТОРА ПРИ ЕКСПЛУАТАЦІЇ ВОДНОГО ТРАНСПОРТУ

Носов П. С. – канд. техн. наук, доцент кафедри судноводіння Херсонської державної морської академії, Україна.

Попович І. С. – д-р псих. наук, професор кафедри психології Херсонського державного університету, Україна.

Зінченко С. М. – канд. техн. наук, доцент кафедри управління судном, завідувач лабораторією електронних симуляторів Херсонської державної морської академії, Україна.

Кобець В. М. – д-р економ. наук, професор кафедри інформатики, інженерії програмного забезпечення та економічної кібернетики Херсонського державного університету, Україна.

Сафонова Г. Ф. – канд. техн. наук, доцент кафедри фундаментальних дисциплін Херсонського політехнічного фахового коледжу державного університету «Одеська політехніка», Україна.

Аппазов Е. С. – канд. техн. наук, доцент кафедри інноваційних технологій та технічних засобів судноводіння, Херсонська державна морська академія, Україна.

АНОТАЦІЯ

Актуальність. У статті запропоновано підхід автоматизованої ідентифікації мотиваційної моделі навігаторів при управлінні морським транспортом. Запропоновано алгоритми вилучення даних в результаті людино-машинного взаємодії навігатора з електронними системами управління судном при виконанні навігаційних операцій підвищеної складності.

Мета. Метою дослідження є застосування формального і алгоритмічного підходів до вилучення даних мотиваційної моделі навігатора для запобігання аварій на водному транспорті.

Метод. Пропонується ідентифікація детермінованних проявів розумової діяльності навігаторів за допомогою візуальної концепції геометричної теорії груп. Такий підхід забезпечив наочне системо-логічне поєднання діагностичних методів що спрямовані на визначення мотиваційних центрів штурмана і процесів професійної діяльності, наприклад при виконанні маневрів. Ключовим показником ідентифікації вважається параметр активності штурмана «rpm_port», що впливає на швидкість судна і є маркером посилення його фізіологічної активності. Такий підхід корисний для ідентифікації тимчасових фаз при маневруванні, що явно вказують на зміну мотиваційного стану навігатора. Даний аспект був доведений на підставі результатів дендрограмми Уорда, кількох статистичних методів і прикладного програмного забезпечення. Отримані результати досліджень дозволяють прогнозувати мотиваційні стани навігатора у критичних ситуаціях.

Результат. З метою підтвердження запропонованого формально-алгоритмічного підходу був проведений експеримент з використанням навігаційного симулятора Navi Trainer 5000. Автоматизований аналіз експериментальних даних дозволив сформувати мотиваційну карту навігатора і визначити модель прийняття рішень що впливають на процеси управління судном у складних ситуаціях.

Висновок. Запропоновані підходи дослідження дозволили автоматизувати процеси вилучення даних що вказують на принципи прийняття рішень навігатором. Результативність запропонованого підходу була обгрунтована за результатами автоматизованої обробки експериментальних даних і побудованих ознакових деревоподібних просторів прийняття рішень.

КЛЮЧОВІ СЛОВА: системи ідентифікації мотивації, системи автоматизованої обробки даних, моделювання моделей прийняття рішень, комп'ютерні стимулятори, аналіз людського фактора, автоматизовані системи управління.

УДК 004.942:656.61.052

АВТОМАТИЧЕСКОЕ ОПРЕДЕЛЕНИЕ МОДЕЛИ МОТИВАЦИИ НАВИГАТОРА ПРИ ЭКСПЛУАТАЦИИ ВОДНОГО ТРАНСПОРТА

Носов П. С. – канд. техн. наук, доцент кафедры судовождения Херсонской государственной морской академии, Украина.

Попович И. С. – д-р псих. наук, профессор кафедры психологии Херсонского государственного университета, Украина.

Зинченко С. Н. – канд. техн. наук, доцент кафедры управления судном, заведующий лабораторией электронных симуляторов Херсонской государственной морской академии, Украина.

Кобец В. Н. – д-р эконом. наук, профессор кафедры информатики, инженерии программного обеспечения экономической кибернетики Херсонского государственного университета, Украина.

Сафонова А. Ф. – канд. техн. наук, доцент кафедры фундаментальных дисциплин Херсонского политехнического профессионального колледжа государственного университета «Одесская политехника», Украина.

Аппазов Э. С. – канд. техн. наук, доцент кафедры инновационных технологий и технических средств судовождения, Херсонская государственная морская академия, Украина.

DOI 10.15588/1607-3274-2021-3-13

АННОТАЦИЯ

Актуальность. В статье предложен подход автоматизированной идентификации мотивационной модели навигаторов при управлении морским транспортом. Предложены алгоритмы извлечения данных в результате человеко-машинного взаимодействия навигатора с электронными системами управления судном при выполнении навигационных операций повышенной сложности.

Цель. Целью исследования является применение формального и алгоритмического подходов к извлечению данных мотивационной модели навигатора для предотвращения аварий на водном транспорте.

Метод. Предлагается идентификация детермининированных проявлений мыслительной деятельности навигаторов с помощью наглядной концепции геометрической теории групп. Такой подход обеспечил наглядное систематико-логическое сочетание диагностических методов, направленных на определение мотивационных центров штурмана и процессов профессиональной деятельности, например при выполнении маневров. Ключевым показателем идентификации считается параметр активности штурмана «rpm_port», влияющий на скорость судна и являющийся маркером усиления его физиологической активности. Такой подход полезен для идентификации временной фазы при маневрировании, что явно указывает на изменение мотивационного состояния навигатора. Данный аспект был доказан на основании результатов дендрограммы Уорда, нескольких статистических методов и прикладного программного обеспечения. Полученные результаты исследований позволяют прогнозировать мотивационные состояния навигатора в критических ситуациях.

Результат. С целью подтверждения предложенного формально-алгоритмического подхода был проведен эксперимент с использованием навигационного симулятора Navi Trainer 5000. Автоматизированный анализ экспериментальных данных позволил сформировать мотивационную карту навигатора и определить модель принятия решений влияющих на процессы управления судном в сложных ситуациях.

Вывод. Предложенные подходы исследования позволили автоматизировать процессы извлечения данных указывающих на принципы принятия решений навигатором. Результативность предложенного подхода была обоснована по результатам автоматизированной обработки экспериментальных данных и построенных признаковых древовидных пространств принятия решений.

КЛЮЧЕВЫЕ СЛОВА: системы идентификации мотивации, системы автоматизированной обработки данных, моделирование моделей принятия решений, компьютерные симуляторы, анализ человеческого фактора, автоматизированные системы управления.

ЛІТЕРАТУРА / ЛИТЕРАТУРА

1. Yundong H. Work notivation and operational risk assessment. A new direction for organizational behavior studies / H. Yundong // SSRN Electronic Journal. – 2016. DOI:10.2139/ssrn.2758698.
2. Edwards T. Motivating operations and negative reinforcement / T. Edwards, A. Poling // Perspectives on behavior science. – 2020. – Vol. 4, No. 43. – P. 761–778. DOI: 10.1007/s40614-020-00266-8.
3. The impact of using virtual reality on student's motivation for operating system course learning / [M. A. A. Ahmad, H. El. Bakry, A. E. D. Mohamed, M. B. Senouy] // Journal of E-Learning and Knowledge Society. – 2020. – Vol. 2, No. 16. – P. 25–33. DOI:10.20368/1971-8829/1135076.
4. Identification of "Human error" negative manifestation in maritime transport / [P. S. Nosov, A. P. Ben, V. N. Mateichuk, M. S. Safonov] // Radio Electronics, Computer Science, Control. – 2018. – Vol. 4, No. 47. – P. 204–213. DOI:10.15588/1607-3274-2018-4-20.
5. Approaches going to determination periods of the human factor of navigators during supernumerary situations / [P. Nosov, A. Ben, A. Safonova, I. Palamarchuk] // Radio Electronics, Computer Science, Control. – 2019. – Vol. 2, No. 49. – P. 140–150. DOI:10.15588/1607-3274-2019-2-15.
6. Nosov P. S. Diagnostic system of perception of navigation danger when implementation complicated maneuvers / [P. S. Nosov, S. M. Zinchenko, I. S. Popovych et al.] // Electronics, Computer Science, Control. – 2020. – Vol. 1. – P. 146–161. DOI:10.15588/1607-3274-2020-1-15.
7. Zinchenko S. M. Improving the accuracy and reliability of automatic vessel moution control systems / [S. M. Zinchenko, A. P. Ben, P. S. Nosov et al.] // Radio Electronics, Computer Science, Control. – 2020. – Vol. 2. – P. 183–195. DOI:10.15588/1607-3274-2020-2-19
8. A system to analyze users behaviors in their applications / [C. Frisson, S. Malacria, G. Bailly, T. Dutoit] // Inspector-Widget. – 2016. – P. 1548–1554. DOI:10.1145/2851581.2892388.
9. Automatic collision avoidance with multiple targets, including maneuvering ones / [S. M. Zinchenko, P. S. Nosov, V. M. Mateychuk et al.] // Radio Electronics, Computer Science, Control. – 2019. – Vol. 4. – P. 211–221. DOI:10.15588/1607-3274-2019-4-20.
10. Comparative analysis of emotional personality traits of the students of maritime science majors caused by long-time staying at sea / [R. Shevchenko, I. Popovych, L. Spytska et al.] // Revista Inclusiones. – 2020. – Vol. 7. – P. 538–554.
11. Research of psychophysiological characteristics of response to stress situations by future sailors / [R. Shevchenko, V. Cherniavskyi, S. Zinchenko, M. Palchynska et al.] // Revista Inclusiones. – 2020. – Vol. 7. – P. 566–579.
12. Development of evaluation procedures for watchkeeping officers using bridge simulator / [M. Solmaz, B. Özsever, A. Güllü, C. Meşe] // TransNav, the International journal on marine navigation and safety of sea transportation. – 2020. – Vol. 14. – P. 565–571. DOI:10.12716/1001.14.03.07.
13. Prokopchuk Y. A. Sketch of the formal theory of creativity / Y. A. Prokopchuk. – Dnepr : PSACEA, 2017. – P. 452.
14. Баранов В. В. Процессы принятия управляющих решений, мотивированных интересами / В. В. Баранов. – Физматлит, 2005. – 296 с.
15. Irodov V. F. Decision-making during limited of experiments with multiple criteria / V. F. Irodov, R. V. Barsuk // Radio Electronics, Computer Science, Control. – 2020. – Vol. 1. – P. 200–208. DOI:10.15588/1607-3274-2020-1-20.
16. Melnyk K. V. Decision support technology for sprint planning / K. V. Melnyk, V. N. Hlushko, N. V. Borysova // Radio Electronics, Computer Science, Control. – 2020. – Vol. 1. – P. 135–145. DOI:10.15588/1607-3274-2020-1-14.
17. Subbotin S. A. The fractal analysis of sample and decision tree model / S. A. Subbotin, Y. A. Gofman // Radio Electronics, Computer Science, Control. – 2020. – Vol. 1. – P. 98–107. DOI: 10.15588/1607-3274-2020-1-11.

DOI 10.15588/1607-3274-2021-3-13

18. He Y. A decision-making model with utility from anticipation and disappointment / Y. He, J. Dyer, J. Butler // Journal of Multi-Criteria Decision Analysis. – 2019. – P. 26. DOI: 10.1002/mcda.1657.
19. Lu J-B. Implementation of Stochastic Analysis in Corporate Decision-Making Models / [J-B Lu, Z-J Liu, D. Tulenty et al.] // Mathematics. – 2021. – P. 9. DOI: 10.3390/math9091041.
20. Rational irrationality a two-stage decision-making model / [R. Acevedo, P. Fernández, J. Mora, E. Aponte] // Advances in Decision Sciences. – 2021. – P. 25. DOI: 10.47654/v25y2021i1p1-39.
21. Pleskacz K. Understanding of navigational information systems / K. Pleskacz, J. Uriasz // Annual of navigation. – 2012. – Vol. 19. – P. 121–132. DOI:10.2478/v10367-012-0010-z.
22. Interface design in the ship navigation information system / [L. Wenting, S. Tian, Z. Hong, Y. Ying] // IEEE 11th International Conference on Computer-Aided Industrial Design & Conceptual Design. – 2010. – Vol. 1. – P. 395–400. DOI: 10.1109/CAIDCD.2010.5681326.
23. Experimental study of optimized interface displays of navigation information system / [C. Wang, J. Zhang, H. Yu et al.] // Lecture Notes in Electrical Engineering. – 2015. DOI:10.1007/978-3-662-48224-7_45.
24. Automated identification of an operator anticipation on marine transport / [P. S. Nosov, I. S. Popovych, V. V. Cherniavskyi et al] // Radio Electronics, Computer Science, Control. – 2020. – Vol. 3. – P. 158–172. DOI:10.15588/1607-3274-2020-3-15.
25. Stillwell J. Group Theory / J. Stillwell // In book: Mathematics and Its History. – 2020. – P. 257–282. DOI:10.1007/978-3-030-55193-3_14.
26. Malyutin A. Geometry and topology / Malyutin A., Netsvetaev N. // Journal of Mathematical Sciences. – 2009. – Vol. 3. – P. 10.
27. Huebner M. A systematic approach to initial data analysis is good research practice / M. Huebner, W. Vach, le S. Cessie // The journal of thoracic and cardiovascular surgery. – 2015. – P. 151. DOI:10.1016/j.jtcvs.2015.09.085.
28. Clarke W. Approaches to data analysis / W. Clarke // Clinical trials in neurology, Design, Conduct, Analysis. – 2012. – P. 52–68. DOI:10.1017/CBO9781139032445.007.
29. Weir J.P. Statistical approaches to data analysis / In L. E. Armstrong & W. J. Kraemer (Eds.) // ACSM's Research Methods. – 2015. – P. 325–342.
30. Lehtola V. Sea captains' views on automated ship route optimization in ice-covered waters / V. Lehtola, J. Montewka, J. Salokannel // Journal of Navigation. – 2019. – Vol. 73. – P. 1–20. DOI:10.1017/S0373463319000651.
31. Picu C. Multiple physical stress exposures of sailors on several ships – a longitudinal study / C. Picu, E. Rusu // Physics, Theoretical Mechanics. – 2018. – Vol. 41. – P. 84–93. DOI:10.35219/ann-ugal-math-phys-mec.2018.1.12.
32. Slišković A. Lifestyle factors in Croatian seafarers as relating to health and stress on board / A. Slišković, Z. Penezic // Work. – 2017. – Vol. 56. – P. 1–10. DOI:10.3233/WOR-172501.
33. Degtyarev A. Real surfaces: the topological aspects / A. Degtyarev, I. Itenberg, V. Kharlamov // Lecture Notes in Mathematics book series. – 2000. – Vol. 1746. DOI: 10.1007/BFb0103965.
34. Gregori V. A duality relationship between fuzzy partial metrics and fuzzy quasi-metrics / V. Gregori, J. Miñana, D. Miravet // Mathematics. – 2020. – Vol. 8(9). – P. 1575. DOI:10.3390/math8091575.
35. Chaudhari M. Analyzing risky behavior in traffic accidents / M. Chaudhari, S. Sarkar, D. Sharma // Navigation and transport. – 2020. – P. 464–471. DOI:10.1109/SMC42975.2020.9283330.
36. Smolarek, L. Dimensioning the Navigational Safety in Maritime Transport / L. Smolarek // Journal of Konbin. – 2010. – Vol. 1415. – P. 271–280. DOI:10.2478/v10040-008-0184-6.
37. Kriukova T. L. The questionnaire of controlling (The Adaptation of the Methods WCQ) / T. L. Kriukova, Ye. V. Kuftiak // Journal of an applied psychology specialist. – 2007. – Vol. 3, No. 93. – P. 102–112.
38. Lazarus R.S. Stress, Appraisal and coping / R. S. Lazarus, S. Folkman // New York, Springer Publishing Company. – 1984. URL:https://www.worldcat.org/title/stress-appraisal-and-coping/oclc/609341596.
39. Gathering behavior of groups of people in a city / [C. Quadri, M. Zignani, S. Gaito, G. Rossi] // IEEE International Conference on Smart Computing, SMARTCOMP. – 2018. DOI:10.1109/SMARTCOMP.2018.00025.
40. Pazouki K. Development of automatic mode detection system by implementing the statistical analysis of ship data to monitor the performance / [K. Pazouki, I. Zaman, R. Norman et al.] // The International Journal of Maritime Engineering. – 2020. – Vol. 159. – P. 225. DOI:10.3940/rina.ijme.2017.a3.411.
41. Guo B. Statistics analysis of ship response in extreme seas / B. Guo, E. M. Bitner-Gregersen, H. Sun, J. Helmers // Ocean Engineering. – 2020. – Vol. 119. DOI:10.1016/j.oceaneng.2016.03.060.
42. Eliopoulou E. Statistical analysis of ship accidents and review of safety level / E. Eliopoulou, A. Papanikolaou, M. Voulgarellis // Safety Science. – 2016. – Vol. 85. – P. 282–292. DOI:10.1016/j.ssci.2016.02.001.
43. Identification of marine emergency response of electronic navigation operator / [P. S. Nosov, V. V. Cherniavskyi, S. M. Zinchenko et al.] // Radio Electronics, Computer Science, Control. – 2020. – Vol. 1. – P. 208–223. DOI: 10.15588/1607-3274-2021-1-20.
44. Pinakpani, P. An Algorithmic Approach for Maritime Transportation / [P. Pinakpani, A. Polisetty, G. Bhaskar et al.] // International Journal of Advanced Computer Science and Applications. – 2020. – P. 11. DOI:10.14569/IJACSA.2020.0110296.
45. Criteria System of Emergency Situations Risks Assessment in the Baltic Sea Ports / [D. Bazaras, R. Palšaitis, A. Petraška, A. Zvaigzne] // Transport and Telecommunication Journal. – 2017. – P. 18. DOI: 10.1515/ttj-2017-0024.

DOI 10.15588/1607-3274-2021-3-13