INTELLECTUAL ANALYSIS OF TRANSITIONAL MOTIVATIONAL STATES IN THE EVENT OF CRITICAL SITUATIONS IN MARITIME TRANSPORT BY ECDIS DATA

Nosov P.S.[1]✉, Cherniavskyi V.V.[1], Onyshko D.M.[1], Koretsky O.A.[1,2]

[1] *Kherson State Maritime Academy, Ukraine*

[2] *Jens & Waller GmbH &CO.KG, USA*

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Abstract

This thesis explores the effect of transient motivational states on performance and safety in the context of navigation. The authors use methods for identifying critical psycho-motivational states (CMMS) using p-adic systems and neural network modeling to identify transient CMMS that can lead to errors in navigator decision making. The main results of the article show that emotional stress can greatly affect decision making and the overall safety of navigation. The novelty of study is the use of p-adic systems in the identification of CMMS and the presentation of neural network modeling results. The findings of thesis present important scientific findings for improving the safety and efficiency of navigation.

Introduction

Transient motivational states in a person can manifest themselves during the day and are changes in motivation caused by various factors, such as a change in the emotional state, the level of fatigue, the presence of stressful situations, changing tasks, etc. [1,2]. Transient motivational states can affect a person's behavior and performance, as well as their physical and mental health [3,4].

In the context of navigation, the emotional stress of navigators during navigational watch can manifest itself, for example, when approaching dangerous places, including ship routes with a large number of common transport and other vessels, bridges, harbors, and also in case of adverse weather conditions [5]. There may also be situations related to technical malfunctions on board, unexpected changes in the itinerary or schedule, and other factors that can lead to a strong conflict between professional duties and personal beliefs, causing tension and stress for skippers [6]. Emotional stress can manifest itself in the form of anxiety, anxiety, fear, irritation, and can affect decision making and the overall safety of navigation.

Relevance of research

During the course of a voyage, boatmasters may encounter various factors that can cause emotional stress, including approaching dangerous places, bad weather, technical problems, changes in the itinerary or schedule, and other situations that may lead to conflicts between professional duties and personal beliefs. These tensions can manifest as anxiety, fear and anger, which can affect decision making and the overall safety of navigation and lead to accidents.

Emotional tension among navigators can lead to errors that can affect the safety of navigation. For example, when performing navigational tasks, such as maneuvering in a port or being in conditions of limited visibility, emotional stress can cause uncontrolled movements of the helm, incorrect commands by helmsmen, as well as incorrect determination of the speed and direction of vessel, which can lead to collisions with other vessels, collision with obstacles, and even shipwreck.

In addition, emotional stress can affect decision making in critical situations. For example, in the event of unforeseen circumstances, such as a severe storm or a technical problem on board, navigators may become emotionally stressed and make decisions that are inappropriate for the situation. This can lead to serious consequences such as loss of control of vessel or inability to properly respond to critical situations.

Scientists of maritime powers are deeply studying the influence of human factor on the accident's occurrence. Cases of maritime accidents involving crew errors were reviewed, with particular attention to bridge management. The data was analyzed and key factors influencing errors were identified, including lack of training, incorrect use of electronic charts, and poor communication quality between crew members [1]. Also, in scientific research, the authors of earlier publications used the HFACS (Human Factors Analysis and Classification System) to analyze cases of accidents related to the operation of a vessel. They identified the main categories of errors, including lack of attention, lack of skills, problems with decision making, problems with communication, and problems with work organization [2]. Other authors have investigated marine incidents resulting from human error using TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) and Fuzzy Analytical Hierarchical Process (FAHP). They developed a methodology for assessing and classifying errors and identified the key factors influencing their occurrence [3].

In addition, in the article [10], a review of studies in the field of maritime safety was carried out, with an emphasis on the role of human factors in it, with the aim of integrating safety and human factors aspects in navigation. And in the article [11], an analysis of the factors associated with human error in maritime accidents was carried out, based on a study of incidents that occurred in the past, in order to draw lessons and offer recommendations for improving safety in the future.

All of the above problem areas and scientific research indicate the importance of research in the field of unpredictable emotional navigators' stress. At the same time, the problem remains unresolved due to the complex formalization of reasons that affect the sudden occurrence of a critical situation during the navigational watch.

However, due to objective circumstances, it is difficult for the captain to consider the possible emotional stress of his navigators in real time and provide them with training and training that will help them learn how to effectively control their emotions and make decisions based on objective navigation data. As a result, there is a need to create specialized intelligent systems that work automatically and allow real-time monitoring of dangerous trends in the change in the motivational state of navigators during navigational watch.

Presentation of the main material

Considering the fact that the activity and psychophysiological parameters of navigators represent a large array of data that dynamically changes and depends on difficultly predictable reasons, appropriate formal-logical methods of data processing should be chosen [12]. One of the modern methods that allows obtaining objective results using the categories of information described above is artificial neural networks.

Based on neural networks, it becomes possible to develop systems that are able to detect violations in the operation of navigators based on an analysis of its behavior, for example, based on the analysis of eye movements and gestures. In addition, it is possible to create systems that can determine the level of concentration and fatigue of the operator based on his biological indicators, such as electroencephalogram (EEG) and heart rate [13]. Such systems can be useful for assessing the state of operator and preventing possible errors associated with insufficient concentration and fatigue [14].

So, if we propose an approach for identifying critical psycho-motivational states in critical situations (CMMS), using p-adic systems, then the following approach to their encoding is quite possible, determining the complexity of the situation [15]. This will make it possible to form a training sample for neural networks and conduct simulations to identify transient CMMS.

At the same time, the threshold CMMS itself was identified to have a code (1301):

$$\gamma_0 = 1;\ \gamma_1 = 3;\ \gamma_2 = 0;\ \gamma_3 = 1.$$

After conducting an experiment with the several cadets being involved, the most typical situations were identified as the following: $CMMS_1$=1220, $CMMS_2$=2101, $CMMS_3$=1311, $CMMS_4$=1200 in accordance with the further to be speaking blocks: the core of the motivational structure; achieving difficult goals; predictive performance assessment; compliance with the being performed activities.

Let us determine the distance between typical situations $CMMS_1$ ... $CMMS_4$ and the threshold CMMS* (1301) = 85:

$$\rho\left(\text{CMMS}^*,\ \text{CMMS}_1\right) = 1301 - 1220 = 21;\ (9).$$

$$\rho\left(\text{CMMS}_2,\ \text{CMMS}^*\right) = 2101 - 1301 = 300;\ (48).$$

$$\rho\left(\text{CMMS}_3,\ \text{CMMS}^*\right) = 1302 - 1301 = 1;\ (1).$$

$$\rho\left(\text{CMMS}^*,\ \text{CMMS}_4\right) = 1301 - 1200 = 0101;\ (17).$$

Thus, we accomplish the following order of issues where the conditional distance to the threshold MMS *are meant to be depicted in brackets:

CMMS2 > CMMS* > CMMS3 > CMMS1 > CMMS4: (CMMS2: CMMS* (85) + (CMMS2 - CMMS*) (48) = 133; CMMS*: 85; CMMS3: CMMS* (85) + (CMMS3 - CMMS*) (1) = 86; CMMS1: CMMS* (85) - (CMMS* - CMMS1) (21) = 64; CMMS4: CMMS* (85) - (CMMS* - CMMS4) (17) = 68).

At the same time, it is vividly seen that there is evidence of referring to CMMS1 and CMMS4 as not being critical in the chain of orders. Besides, they did highly chance to withstand in the current position until the end of the being performed task without any incident. In its turn, CMMS2 and CMMS3 are really noticed to be delivering a real threat of accidents when performing a navigation task.

Let us analyze the experimental data using the results of the survey of sea navigators in the form of CMMS and the factors of ship management applying the NTPRO 5000. The obtained data of the navigation simulator permitted to make the model in the form of a graphic spatial trajectory of the ship and a cluster of points defined as CMMS1-4 and CMMS* be built.

As a result of modeling using automated neural networks, data were obtained indicating a significant influence of transient motivational processes on the perception of information by navigators in critical situations (Fig. 1).

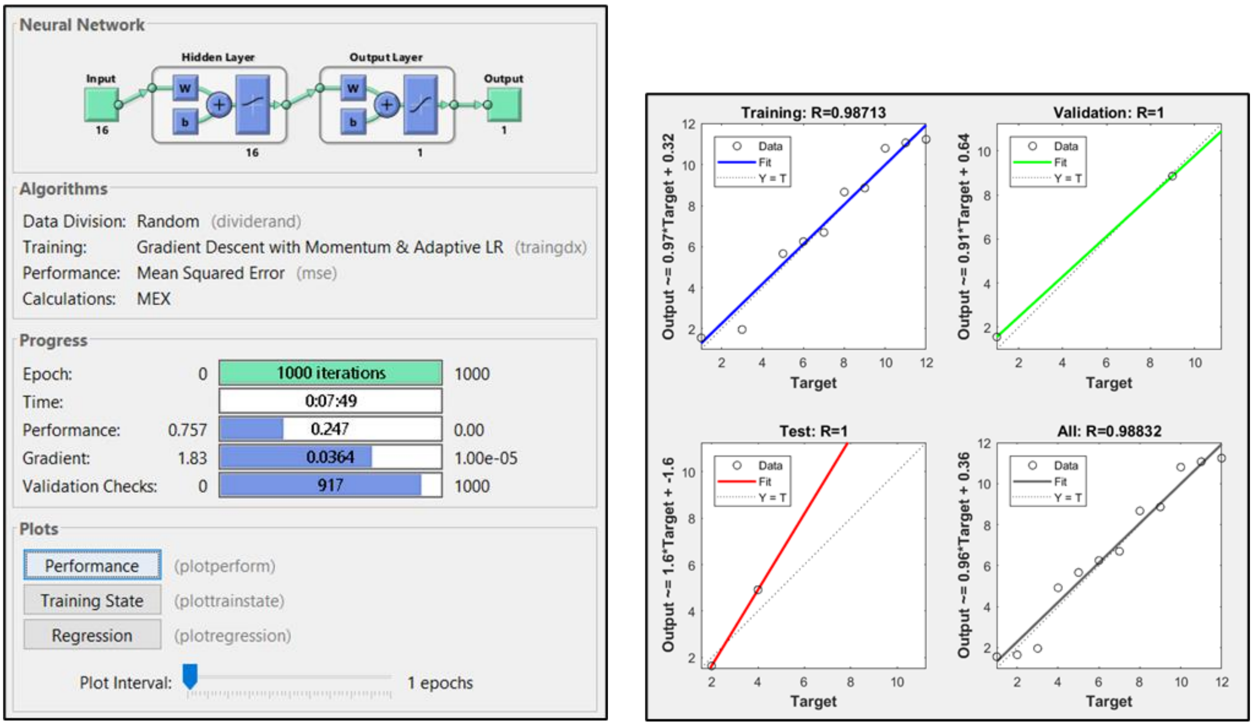

Figure 1. *Modeling the impact of transitional motivation on safety*

Thus, when the target value was applied to the input of the model, an output value was obtained that was close to 1.6 times the target value, offset by -1.6. Thus, there are some deviations that are not random and may lead to a discrepancy in the understanding of the navigation situation.

In turn, "Best Validation Performance is 0.16252 at epoch 74" means that the model showed the best performance on the validation dataset (a dataset that was not used for training, but on which the model is tested during training) at the 74th training epoch (Fig. 2).

Based on the obtained values, it can be assumed that this neural network was successfully trained. The gradient value of 0.036377 at the 1000th training epoch indicates that the network training was stable and the gradient (learning rate) was not too high or too low. The value of the accuracy score on the 917-validation data at the 1000th epoch also indicates that the network has successfully trained and can correctly classify the data. The learning rate value of 0.16997 at the 1000th epoch indicates that the learning rate was optimal and did not lead to overfitting or underfitting of network.

From the data obtained, it becomes clear that the deviation from forecast does not depend on the learning ability of network, since She was successfully trained in all respects. In turn, there is the fact that transient processes in CMMS have an impact on the perception of navigation situation and require deep scientific analysis [16]. This calls for taking the necessary measures to improve automated systems for identifying transient CMMS and developing intelligent decision support algorithms in maritime transport [17,18].

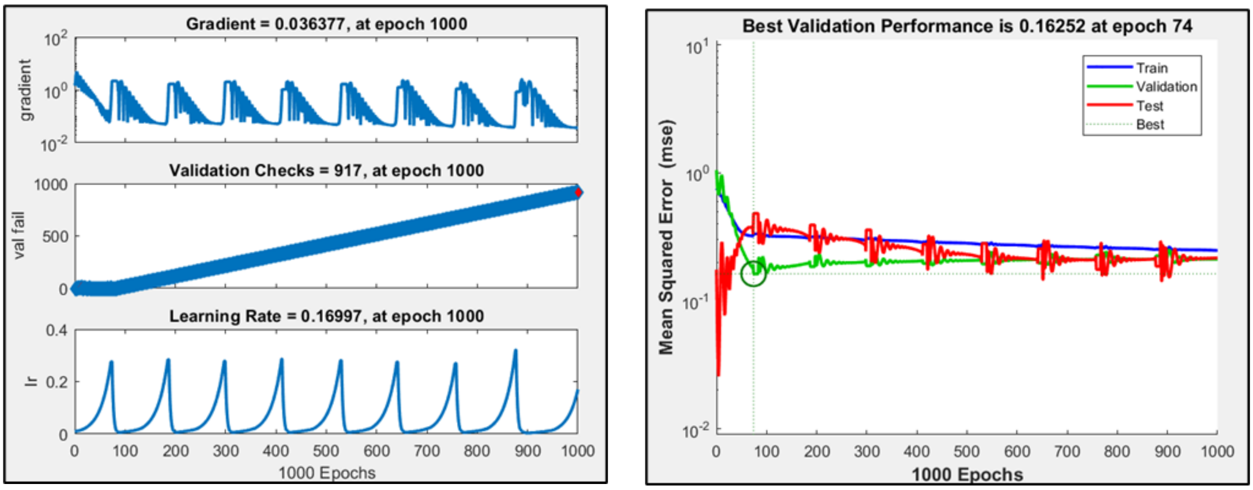

Figure 2. *Learning outcomes of a neural network for predicting critical situations*

Conclusions

Thus, in the thesis considered various aspects related to safety and efficiency of navigation, as well as investigated the factors influencing occurrence of errors and accidents associated with the management of vessel. An important proposal of thesis is the approach of identifying critical psycho-motivational states (CMMS) using p-adic systems, which allows simulation to identify transient CMMS. The results of neural network modeling were also presented, which showed a significant discrepancy in the forecast of navigator actions during transient critical CMMS, which may lead to errors in the perception of navigation information. At the same time, it was found that model showed the best performance on validation dataset. Overall, the article presents important scientific findings that can help improve the safety and efficiency of navigation.

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Authors' information

Pavlo Nosov, Ph.D., Associate Professor, Associate Professor of Navigation Department, Kherson State Maritime Academy, Kherson, Ukraine, ORCID ID: 0000-0002-5067-9766.

Vasyl Cherniavskyi, Doctor of Education, Professor, Rector, Kherson State Maritime Academy, Kherson, Ukraine, ORCID ID: 0000-0001-7551-4186.

Dmytro Onyshko, Senior Lecturer, Department of Ship Handling at Sea, Kherson State Maritime Academy, Kherson, Ukraine.

Oleksiy Koretsky, Deep-Sea Master, Jens & Waller GmbH &CO.KG, postgraduate, Kherson State Maritime Academy, Kherson, Ukraine.