DEVELOPMENT OF INTELLIGENT IDENTIFIER OF MARINE NAVIGATOR SUSTAINABLE STRESS

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Introduction. The essence of the entire training of a navigator is to reduce practical stressful situations to routine ones, which will be perceived everyday regardless of the circumstances, with theoretical knowledge and training. Unfortunately, the number of various factors that affect the watchkeeper and the variability of their influence create constant stressful situations from which the mate must find a way out. These can be both external factors such as the crowding of ships, weather conditions, imperfection of equipment, etc., and caused by the state of health, psychophysiological and psychological factors [1-7].

The main material of the study. One of these factors is the so-called circadian rhythm cyclic fluctuations in the intensity of various biological processes associated with the change of day and night (Fig. 1). Despite the connection with external stimuli, circadian rhythms have an endogenous (internal causes) origin, representing, thus, the "internal clock" of the body. It is he who regulates our periods of activity and desire to sleep during the day [8,9].

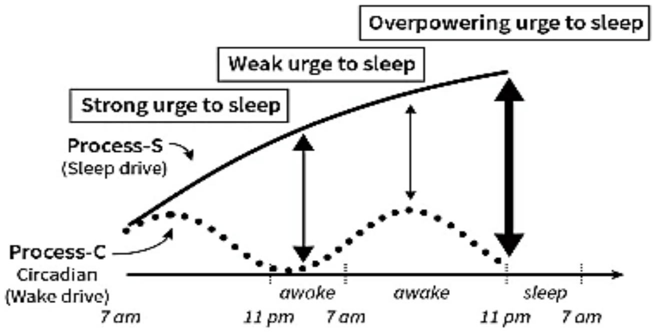
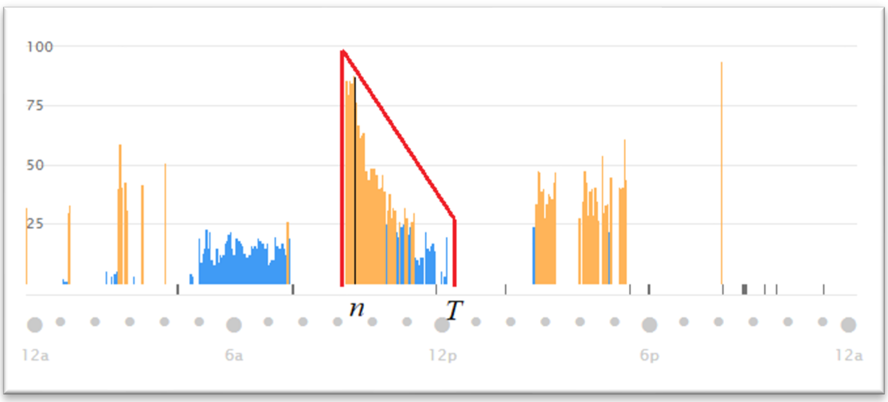
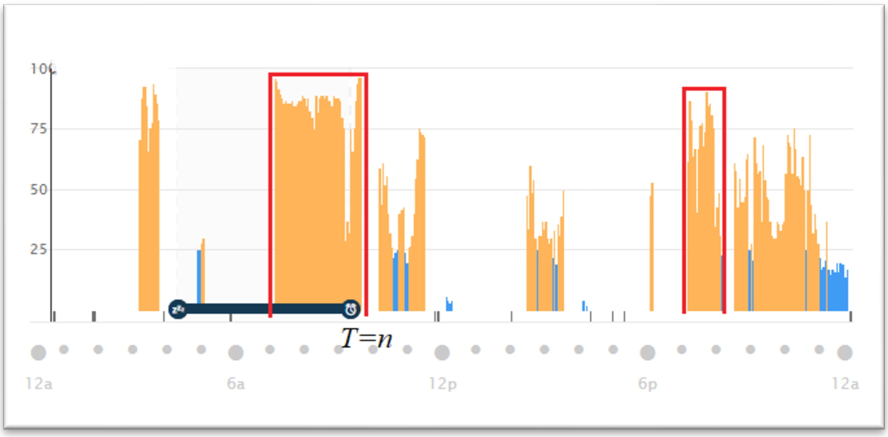


Fig. 1 Circadian rhythm (Matthew Walker «WHY WE SLEEP»)

In Figure 1, we see a graph of the circadian rhythm of a healthy person and the peaks of his activity. It is the circadian rhythm that regulates periods of alertness and sleepiness. Its very essence is that it acts regardless of what happens during the day, being adjusted only by external factors, constantly adjusting to the day-night rhythm, and therefore, despite the fact that a person has slept enough during the day, it will provoke a feeling of drowsiness at the appropriate time at night, and therefore suppress the vigilance of the watch keeper and reduce his ability to critically and adequately perceive the situation and analyze its variables, which can lead to a disaster. Based on all of the above on board of «MV Alexander» of Reedier Jens & Waller GmbH & Co. KG, a number of experiments were conducted on the influence and dependence of the states of excitation and decline (states of possible errors) on the time of rest and the presence of the deep sleep factor (Fig. 2 a, b).



a



b

Fig. 2. Phases of prolonged stress the navigator on captain's bridge

From the data obtained from work of assistant captain, during the navigational watch, graphs of stress activity were analyzed. As can be seen from the graphs, two forms of navigator stress activation are visually identified. In the first case (Fig. 2. a), there is a surge and a rapid decline in navigator's stress, which indicates the presence of internal control and focus on the navigation situation. In second case, the stress phase lasts up to three hours at peak rates (Fig. 2. b). This mode significantly affects the quality of navigator's work, increasing the level of risk and reducing the performance of entire navigational watch. It has also been noted that presence of short deep sleep affects the structure and timing of prolonged stress at peak levels.

It should be considered that for each individual navigator, under the conditions of circadian rhythm, the phase of deep sleep, the complexity of navigation environment, the exposure time to peak stress is different. At the same time, it is important to develop an intelligent automated identifier that will allow real-time determination of the dangerous phase and duration of stress.

In order to select the most significant situations for the analysis of maritime safety, we will consider the threshold phases in terms of navigator time. At the same time, it is important to consider that before starting an automated analysis of peak stress loads, it is necessary to provide a sufficient sample of classifying indicative stress phases for each navigator. The more data that we can operate with, the more likely it will be possible for the automated system to identify the phase that directly affects the occurrence of a critical situation due to the navigator human factor.

The formation of the peak stress phase of the navigator can be generally represented as a pseudo-random sequence of the form: $L \cdot S_n = \left(Y_1 + ... + Y_n \mid ES = 0,\ \mathrm{Var}S_1 \in (0, \infty)\right)$ [10,11]. Then, the point $T = \min\{n : S_n < 0\}$, we define as the end of the critical phase of stress for the navigator on the trajectory (Fig. 3).

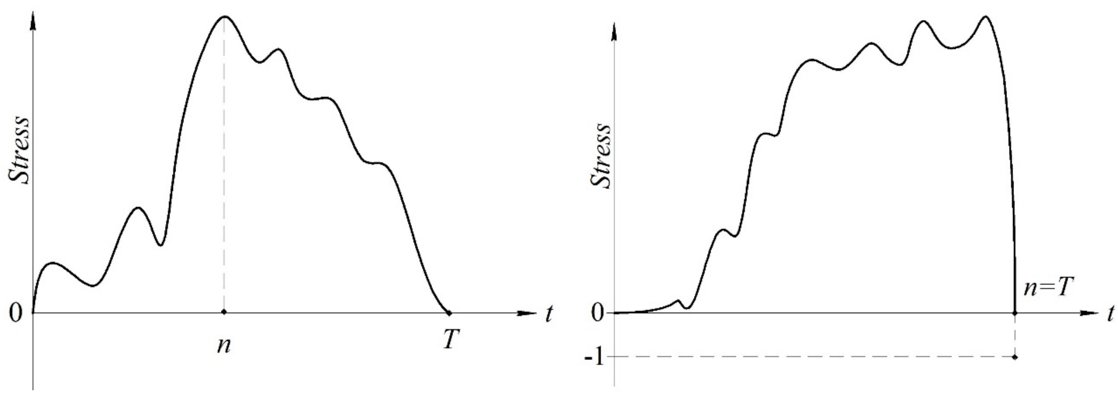


Fig. 3. Graphs of phase stress of navigator

Consider two cases, Ph_1 and Ph_2 (1):

$$Ph_1\left(\frac{(S_1,\dots,S_T)}{\sigma\sqrt{T}}\,|\,T>n,\ or\,T\gg n\right);\quad Ph_2\left(\frac{(S_1,\dots,S_T)}{\sigma\sqrt{T}}\,|\,T=n,\ or\,T\approx n\right).$$

Let us define a threshold that indicates the boundary of stress duration, after which, with a high degree of probability, critical consequences occur, leading to emergency situations, accidents, etc. From this point of view, the consideration of a random function $\hat{X}_n(\cdot)$ that forms the navigator's stress phase trajectory of form [12] $\left(\hat{X}_n(\cdot)\,|\,T\approx n\right)\xrightarrow[t\geq 1]{d}\left(W_{ex}(\cdot)\right)$, $P(T=n)>0$ will be of the greatest interest. If we add to this process the negative mental activity of navigator in form of a stupor, which was considered above, then it is logical to introduce a negative stress scale of level -1: $P(T=n)=\frac{1}{n}P(S_n=-1)$.

Such a value will indicate the occurrence of a waking sleep state for the navigator during navigational watch. It is this state that we associate with the absence of a deep sleep phase in the navigator on the eve of watch. And it is this condition that most strongly affects the increase in the risk of navigation. In order to identify such feature sets, we will simulate the corresponding fuzzy membership functions [13,14] (Fig. 4).

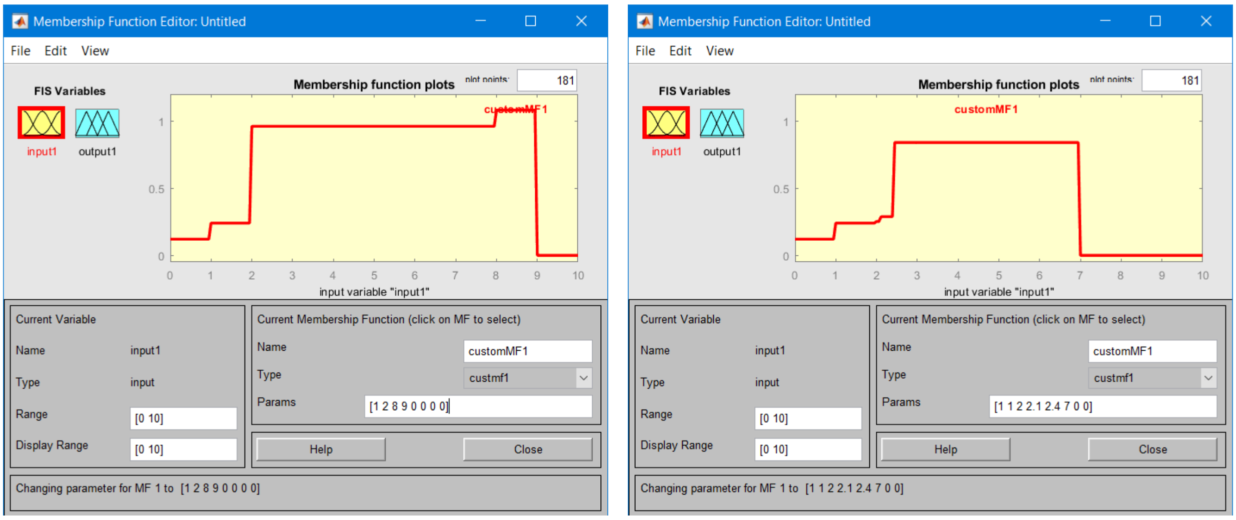


Fig. 4. Modeling fuzzy sets of the navigator critical state

This will make it possible to identify dangerous psychological states of the navigator by means fuzzy inference regulator in real time for the captain to make corrections in keeping watch [15-22].

Conclusion. The proposed approach will make it possible to adapt the system for identifying navigators' stress states by means of analyzing their mental activity, starting from simulator training and ending with a real watch on a vessel. The formation of a knowledge base to intelligent system for identification and watch adjustment will significantly reduce the risk of accidents in maritime transport.

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