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FORMAL IDENTIFICATION OF THE HUMAN FACTOR INFLUENCE OF THE NAVIGATOR IN MODELS OF RANDOM BRANCHING PROCESSES

Koretsky O., Makarchuk D., Nosov P.
Kherson State Maritime Academy

Introduction. The process of determining the set of indices, which can indirectly identify the psychophysiological state of a navigator, faces difficulties in correlating them with the navigational situation [1-3]. Also, if we consider the dynamics of changes of these indicators in time, we can conclude that they are branching processes of individual perception of a navigation situation and, as a consequence, the body's reaction – physiology [4-8]. In view of the difficulty of identifying the factors influencing the physiological reaction of the navigator, which increases the risk of a critical situation, initially we should consider the processes of perception as a random sequence, focused on some primary state [9-12]. However it should be taken into account that in spite of all complexity of identification of negative influence of the human factor it is possible to assert, that the nondegenerate process as a chain of effective decisions of the navigator testifies to availability of safe control of the vessel [13-15]. If the process is abandoned at a certain stage without reaching the final point of the ship's route, it indicates an obvious strategic mistake in ship's control. Also, if the process of ship control becomes endless, looping, for example, when performing maneuvers of approach to a berth during mooring, etc., it is also an indicator of human error in view of biased perception of the navigational situation.

Thus, branching processes of ship control within the framework of evolutionary random algorithms of decision-making by the navigators on the basis of Galton-Watson approaches are considered [16-18].

Random sequence , $Z_0, Z_1, Z_2 ...,$ where Z_n is the number of particles in the n-th generation. It is also important to denote the set of independently equally distributed random variables $X\left(X_i^{(n)}\right)_{i,n=1}^{\infty}$ as the number of descendants of the i-th particle in the n-th generation, where $P\left(X \in \mathbb{N} \cup \{0\}\right) = 1$. If we consider in practice of sea navigation this array of equally distributed random variables can be represented by a navigation chart with indicated depths, navigation objects, ships-targets etc. (Fig. 1). Then each discrete time section of navigation situation development and consequently navigator's reaction to it can be written by formula: $Z_{n+1} = X_1^{(n)} + X_2^{(n)} + ... + X_{Z_n}^{(n)}$. At each new moment of time t_i+1 new random variables are "born" in a pattern: $Z_0 = 1;\ Z_1 = X_1^{(1)};\ Z_2 = X_1^{(2)} + X_2^{(2)} + ... + X_{Z_1}^{(Z)}$

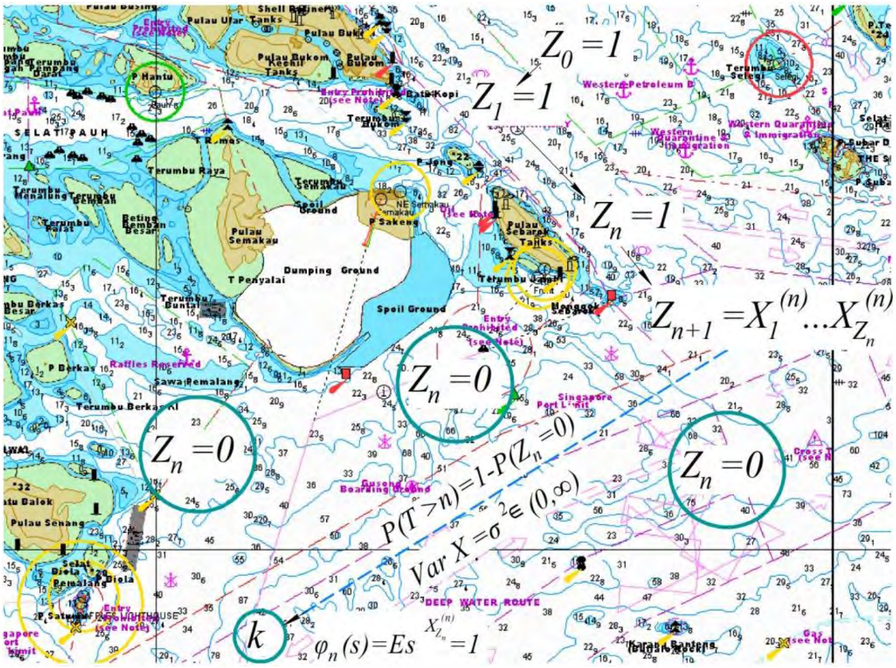

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Figure 1. Distribution of random variables on the map

In view of the discreteness of the formation of slice-states □ $\cup\{0\}$, then these processes can be represented in the form of a Markov chain [19]. Where each state has or has not a certain solution or some number of solutions, each of which leads to the next discrete state. In turn, non-resolutions at a certain stage can lead to degenerate processes T , $T=\min\{n\geq 1:\ Z_n=0\}$ that have no resultant solutions $\sum_{\varnothing}=0$.

As a part of the study it is important to determine the likelihood of the risk of degeneration of the chain of actions, that is, the transition to a state with no effective solutions from the side of the navigator: $q=P(T<\infty)=\lim_{n\to\infty}P(T\leq n)=\lim_{n\to\infty}P(Z_n=0)$

Thus, there is a problem of definition of such conditions in which degeneration of processes of effective decision-making by the navigator will not be observed. It is also important to understand that number and quantity of random variables $X_1^{(n)}\ldots X_{Z_n}^{(n)}$ can represent a separate set not only navigational parameters as depth, but also a number of others: course and speed of a vessel; weather conditions and maneuvering characteristics; experience of a navigator; psychophysiological condition and others. In this way, the discrete state itself cannot have the same set of parameters at every discrete point in time. The complexity of perception of a state involves transforming its into metadata that allow decisions to be made. It is also necessary to take into account that each previous state is related to the present one and the derivative function of the number of particles in general form will be equal to: $\varphi_n(s)=E\,s^{Z_n}=\varphi(\varphi\ldots\varphi(s)\ldots)$where $E\,s^{Z_n}$-is expected value. This indicates that the processes are pseudorandom, since we cannot formally represent the nature of transitions between them. The specification of the number of transitions to new states allows us to state that the process has a final goal-state k. Then, the derivative function φ_2 will be equal to: $\varphi_2(z) = E\, s^{X_1^{(2)}+X_2^{(2)}+\ldots+X_{Z_1}^{(2)}} = \sum_{k=0}^{\infty} P(Z_1 = k)\varphi^k(s)$

In this case the value of $\varphi_n(s)$ lies in the range of $[0\ldots1\ldots n]$, where $n>1$, and the most stable is such that $\varphi_n(s)=1$. In this case, the process of phased decision-making does not degenerate, $P(T>n) = P(Z_n>0) = 1-P(Z_n=0) \Rightarrow \ddot{P}_n = 1-\varphi_n(0)$

At step n +1 we have a probability such that it does not contradict the theorem of Kolmagorov $P_{n+1} = g(P_n);\ P_{n+1} - P_n = -\dfrac{P_n^2\left(\sigma^2+\varphi(1)\right)}{2}$ that in the case of $EX=1 \Rightarrow EZ_n = 1 = \varphi_n'(1)$ defines the condition where $VarX = \sigma^2 \in (0,\infty)$

Thus it is necessary to determine the non-irreducibility of the decision-making process at some moment "t", and we will consider that the influence on its degeneration will depend on the negative manifestation of the human factor. Consequently, it is important to define the conditions of resistance to degeneracy, when $\left(\dfrac{2Z_{[n,t]}}{\sigma^2 n}\middle| Z_n>0 \right)_{0\le t\le 1} \to Z^+ \to e^{-x}$

Let us denote the influence of the human factor as λ , and the mathematical expectation, according to the Laplace transform , will be: $E\,e^{-\lambda Z^+(1)} = \dfrac{1}{1+\lambda},\ \lambda \ge 0$

The effect of λ can be described by the probability of degeneration at the junction of the two states of the system. $P\left(Z_n>0,\ Z_{n+\left[\frac{n}{\lambda}\right]}=0\right)$ where the influence of human factors on the effectiveness of branching decision-making processes is decisive

The main problem of research development is the inevitability of building a local-individual classification of the perceived navigational situation. Because unlike pharma classical models, influence of λ on every particular case cannot be unified in relation to other navigators. That is why it is necessary to define an individual algorithm of feature space forming, which is more complex and multivector in its parameters than a navigation chart. Taking into account all told above and in view of insufficient technical possibilities of identification of λ in a full spectrum, we will put forward a hypothesis that for the decision of a problem in determining the impact of λ for the individual navigator it will be enough to define spaces of states from which follows degeneracy of a kind $Z_{n+\left[\frac{n}{\lambda}\right]}=0$. For this purposes is necessary to define the maximum possible in the conditions of navigational watch the parametric model of the decision-making navigator.

Conclusion. Thus, the formal description of transitions between discrete states on the graph of decision-making space by a navigator in complex navigational conditions has been obtained. Also conditions and probabilities of degeneration of result branches of decision-making in conditions of negative influence of human factor are defined.

Further scientific search should be directed on carrying out of experiment as a result of which definition of the sign space of identification of a navigating situation and accompanying risks, variations and chains of decision-making becomes possible. All this will stimulate formal structural definition of the navigator model as a subject of organizational-technical system of maritime transport, which in turn will lead to the reduction of risks of maritime disasters due to human factor.

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