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TRIBOLOGICAL PROCESS CHARACTERISTICS ON THE BASIS OF A NEURON ACTIVATION MODEL OBTAINED THROUGH THE MULTI-OPTIONAL FUNCTIONS ENTROPY DOCTRINE

It is made an attempt to propose some appropriate models of the friction and wear processes that could happen in the considered structural elements of the engineering units. The uncertainty measure in the given consideration is the entropy of the special hybrid-optional effectiveness functions. Such kind of entropy originates from the Jaynes' principle, being adapted to the subjective entropy maximum principle, with the implementation possibilities to the applicable fields of aviation industry as that follows the readings of the references. The paper theoretically considers the possibility of the multi-optional hybrid functions entropy conditional optimization doctrine applicability with the purpose of discovering substantiated reason for the special hybrid-optional effectiveness functions existence, as well as the reasons for the formula optimality. The neuron model activation function, or a squashing function, of a sigmoid type function like logistic function, formula is obtained with taking into account the degree of uncertainty for a certain type hybrid-optional effectiveness functions. With the help of the variational principle it is shown the optimality of the formula. The evolution of the proposed at this paper approach from the subjective analysis to the hybrid multi-optional functions optimization doctrine implies the use of the hybrid multi-optional functions, as an objectively existing characteristic of a phenomenon, instead of the subjectively preferred, by a human, functions, since no one chooses the objectively existential reality. The approach has a significance of a plausible explanation for the phenomena stipulated by multi-optionality.

Keywords: *tribology, friction, wear, optimization, entropy doctrine, multi-optionality, hybrid optional function, neuron activation, squashing function.*

Introduction. In the sphere of tribology it is very important to operate with the appropriate models of the friction and wear processes that happen in the considered structural elements of the engineering units [1]. In the aircraft airworthiness support and aeronautical engineering maintenance technologies [2] it is an actual problem too. At this, a significant influence of the processes' parameters, their functions uncertainty is a crucial thing.

Tribological characteristics of the modeled behavior of the structural elements, due to the presence of friction and because of that developing wear, somewhat resemble a neuron activation curve in regards to the curve's shape [3] when the process of the gradually deteriorating unit is investigated.

The most up-to-date research in the area of neural networks deals with the extremely complex processes occurring in the networks neuron connections [3]. The neural network structures of the modeled systems and processes can be of different nature. It is always important to apply a suitable approach for such modeling.

State of the problem. The uncertainty measure in the given consideration is the entropy of the special hybrid-optional effectiveness functions. Such kind of entropy originates from the Jaynes' principle [4-6], being adapted to the subjective entropy maximum principle [7], with the implementation possibilities to the applicable fields of aviation industry as that follows the readings of the references [8-11].

The mentioned research scientific gap is the neural networking model that takes into account the significant role of the uncertainty when considering the neuron activation function.

Problem statement. According to the state of the problem, it is required to find the equation of the squashing function [3, p. 47, (1.12)] following a certain variational principle of multi-optional conditional optimality of special hybrid-optional effectiveness functions uncertainty [8], similar to [9-11].

Purpose of the paper. The presented paper is aimed at discovering the substantiated reasons for the activation function formula optimality existence and to demonstrate, on such an example, the multi-optional hybrid functions entropy conditional optimization principle, as a doctrine, applicability.

Problem setting. The problem statement for the current state would be as to find a value extremized with the known view expression used as a neuron model activation function. Consider sigmoid function [3]. It is generally accepted that activation functions or squashing functions have the view of a logistic function [3, p. 47, (1.12)]:

$$\varphi(v) = \frac{1}{1+\exp(-av)}, \tag{1}$$

where v is induced local field or activation potential of the neuron, a is slope parameter of the sigmoid function.

Hybrid Multi-Optional Functions Optimization Doctrine. ***<u>Methods I.</u>*** In order to reveal the optimality of equation (1) [3], it is applied the prototype model of subjective analysis [7], being preceded with the Jaynes' principle [4-6].

<u>Methods II.</u> Now, the evolution of the proposed at this paper approach from the subjective analysis [7] to the hybrid multi-optional functions optimization doctrine implies the use of the hybrid multi-optional functions, as an objectively existing characteristic of a phenomenon, instead of the subjectively preferred, by a human, functions, since no one chooses the objectively existential reality [8-11].

Neuron Model Sigmoid Activation Function. ***<u>Methods III.</u>*** Accordingly to the introduced hybrid multi-optional functions entropy conditional optimization doctrine, the objective functional is being constructed in the following way, [8-11]:

$$\Phi_h = -\sum_{i=1}^{n} h_i \ln h_i + \beta \sum_{i=1}^{n} h_i v_i + \gamma\left(\sum_{i=1}^{n} h_i - 1\right), \tag{2}$$

where h_i is the hybrid multi-optional function (objective fundamental value of the process) deemed to be relevant to the induced local field or activation potential v_i; β, γ are structural parameters (Lagrange multipliers, weight coefficients or intrinsic parameters of the process).

The necessary conditions of functional (2) extremum existence yield

$$h_i = \frac{\exp(\beta v_i)}{\sum_{j=1}^{n} \exp(\beta v_j)}. \tag{3}$$

For any two activation potentials [3, p. 43, (1.3)] v_1 and v_2, at $n=2$

$$h_1 = \frac{\exp(\beta v_1)}{\exp(\beta v_1)+\exp(\beta v_2)}, \qquad h_2 = \frac{\exp(\beta v_2)}{\exp(\beta v_1)+\exp(\beta v_2)}. \tag{4}$$

If each of the induced local fields v_1, v_2, … , v_i is compared with the threshold activation potential v_0,

$$\Phi_{h(0,i)} = -\left(h_{0/i} \ln h_{0/i} + h_{i/0} \ln h_{i/0} \right) + \beta \left(h_{0/i} v_0 + h_{i/0} v_i \right) + \gamma \left(h_{0/i} + h_{i/0} - 1 \right). \quad (5)$$

$$h_{0/i} = \frac{1}{1 + \exp[\beta(v_i - v_0)]}. \quad (6)$$

Comparing equations (6) and (1) one can notice that

$$\beta = -a, \qquad v = v_i - v_0. \quad (7)$$

The hybrid-optional functions entropy

$$H_h = -\sum_{i=1}^{n} h_i \ln h_i, \quad (8)$$

serves as a measure of uncertainty of the hybrid-optional functions h_i. Unfortunately, such measure of uncertainty as expression (8) does not show the direction of the uncertainty and its relative value.

Discussion on the proposed doctrine. ***Methods IV.*** In order to bypass such a difficulty it is proposed to apply the hybrid combined relative pseudo-entropy function developed in reference [11]:

$$\overline{H}_{\max - \frac{\Delta h}{|\Delta h|}} = \frac{H_{\max} - H_h}{H_{\max}} \cdot \frac{\Delta h}{|\Delta h|}. \quad (9)$$

Here in expression (9) $H_{\max}$ is the maximal possible entropy (uncertainty) of the hybrid-optional functions h_i, H_h is the factual entropy (8),

$$\Delta h = \sum_{j=1}^{M} h_j^{+} - \sum_{k=1}^{L} h_k^{-}, \quad (10)$$

where h_j^{+} and h_k^{-} are positive and negative properties hybrid-optional functions respectively, M and L are numbers of the positive and negative properties options:

$$M + L = n. \quad (11)$$

Conclusions. It is discovered an explanation for formula (1) in terms of the multi-optional conditional optimality doctrine for the special hybrid-optional effectiveness functions uncertainty (2-8). Parameters of the hybrid combined relative pseudo entropy function (9-11) need further investigation.

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ХАРАКТЕРИСТИКА ТРИБОЛОГІЧНОГО ПРОЦЕСУ НА ОСНОВІ МОДЕЛІ АКТИВАЦІЇ НЕЙРОНУ ОТРИМАНОЇ ЧЕРЕЗ ЕНТРОПІЙНУ ДОКТРИНУ БАГАТООПЦІЙНИХ ФУНКЦІЙ

У наведеній роботі здійснено спробу запропонувати певні моделі, що підходять, процесів тертя та зношування, котрі могли би відбуватися в конструктивних елементах технічних виробів, які беруться до розгляду. Міра невизначеності у даному розгляді це є ентропія спеціальних гібридно-опційних функцій ефективності. Ентропія такого виду походить від принципу Джейнса, будучи адаптованою до принципу максимуму суб'єктивної ентропії, із імплементаційними можливостями до авіаційних галузей застосування, як це походить зі списку наведених посилань. Стаття розглядає теоретично можливість застосування доктрини умовної оптимізації ентропії багатоопційних гібридних функцій з метою відкриття обґрунтованої причини існування спеціальних гібридно-опційних функцій ефективності, а також причин оптимальності формули, що наводиться. Така формула, що вжита у якості моделі функції активації нейрону, або так звана «*squashing function*», типа сигмоїдальної функції, подібної до логістичної функції, отримується з урахуванням ступеня невизначеності певного типу гібридно-опційних функцій ефективності. За допомогою даного варіаційного принципу було показано оптимальність такого виду формули. Еволюція запропонованого у цій статті підходу, який є розвитком від суб'єктивного аналізу до оптимізаційної доктрини гібридних багатоопційних функцій, передбачає використання вказаних гібридних багатоопційних функцій, у якості об'єктивно існуючої характеристики певного явища, замість описаних суб'єктивно переважних, людиною, функцій, оскільки ніхто не обирає об'єктивно існуючої реальності. Даний підхід має значущість правдоподібного пояснення для таких явищ, обумовлених багатоопційністю.

Ключові слова: трибологія, тертя, зношування, оптимізація, ентропійна доктрина, багатоопційність, гібридна опційна функція, активація нейрону, функція активації.

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