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Entropy methods of human factor analysis applied to the problem of safety of aviation

A system of aviation transportation is considered as an active system. Application of entropy methods is proposed to evaluate adequately the role of human factor. Multi-alternative situations are being considered and the problem of choice is formulated.

Subjective entropy maximum principle.

Two kinds of distributions should be introduced:

1. Object preferences distributions.
2. Subject preferences (rating) distributions.

The principle of subjective entropy maximum [1-4] has been put into the basement of the theory.

The Jaynes' principle [5, 6] is used as a mathematical envelope for the principle mentioned above. To formulate the principle, firstly, we have to introduce the so-called subjective entropy and subjective information.

Proceeding from some theoretical speculations and [1-4], the subject forms his/her own preferences at the set of achievable for his/her goals alternatives with engaging a functional taken in a rather general view:

$$\Phi_\pi = H_\pi + \beta\varepsilon + \gamma \mathrm{H}\,, \qquad (1)$$

where H_π – subjective entropy; $\varepsilon = \varepsilon(\pi, U, \ldots)$ – function of subjective effectiveness, π – subjective preferences function, U – utility function; H – normalizing condition; β, γ – structural parameters which can be considered at different situations as Lagrange multipliers, weight coefficients or endogenous parameters reflecting some certain properties of psych.

$$H_\pi = -\sum_{i=1}^{N} \pi(\sigma_i) \ln \pi(\sigma_i)\,, \qquad (2)$$

where $\pi(\sigma_i)$ – subjective preferences function of an individual distributed upon the set of the attainable alternatives σ_i.

The functional (1) with entropy (2) gets the view of

$$\Phi_\pi = -\sum_{i=1}^{N} \pi(\sigma_i) \ln \pi(\sigma_i) - \beta \sum_{i=1}^{N} \pi(\sigma_i) F(\sigma_i) + \gamma \left[\sum_{i=1}^{N} \pi(\sigma_i) - 1 \right], \qquad (3)$$

where $F(\sigma_i)$ – subjective cognitive function of the individual.

Then, the subjective information necessary to transform the system of the individual's subjective preferences uncertainty from the state 1 into the state 2 will be

$$I_\pi^{(1-2)} = H_\pi^{(1)} - H_\pi^{(2)}\,. \qquad (4)$$

In an analogous way to (1)-(4), it is constructed for ratings.

Let us designate

$$H_{\xi} = -\sum_{j=1}^{M} \xi(j) \ln \xi(j) \qquad (5)$$

as the subjective entropy of the subjective rating preferences $\xi(j)$ of an individual.

It allows giving a quantitative estimation to the degree of the subjective rating preferences $\xi(j)$ uncertainty being determined at the set of the rated subjects (individuals) j :

$$\xi_j \in (0 \ldots 1); \qquad \left(j \in \overline{1, M}\right). \qquad (6)$$

The entropy paradigm in the context of expressions (1)-(6) is an effective tool of the research dealing with the different kinds of uncertainties [1-32].

Entropy space has its own structure illustrated in Figure 1.

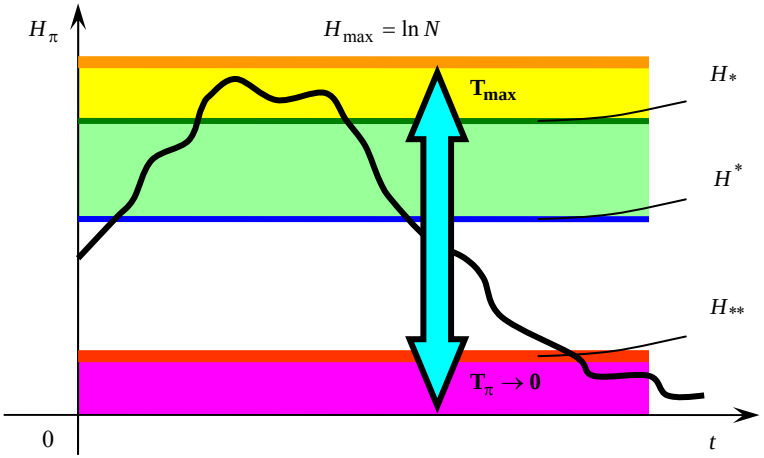

Fig. 1. Structure of the subjective entropy space

Here (see Fig. 1) we can use a supposition about existence of the thresholds of the characteristics mentioned above [4].

Several thresholds were introduced in [3]. First of all such thresholds define the levels of the entropy of a decision making – the choice of a strategy or alternatives. It is designated as H^*.

It means that two conditions are fulfilled:

1: $H_{\pi} \le H^*$ at the time t^*.

2: $\frac{dH_{\pi}}{dt} < 0$ at the moment of t^*.

Secondly, it is supposed that another threshold H_{**} defines the level, down of which there is an area of the ratings utilitarism (dictator's regime).

At last there exist such a level of entropy that the only alternative seems to be available, and distribution of preferences becomes singular. In this case the state (condition) of psych could be named *"Zombie Level"*. It means by the way that there are no resources in the system in order to drive the psych of the subject out from this state.

Exceeding the other threshold level H_* puts the psych down into a hysteria if $H \geq H_*$.

The same picture is for rating preferences and social problems.

There is also the subjective risk introduced in [4], analogue to the Bayes' risk. Dynamics of the preferences. Rating preferences for collective decision making. Collective subject implies aggregation of object preferences.

Examples of unsatisfactorily decision making.

Crashes prove the highest price. Pilots are to be trained. These are the areas of practical application of the entropy theory. Many alternatives, high uncertainty (entropy), and risk, are to be taken into account. It is obvious that the higher the level of the entropy at the moment of the decision making the more probability of a wrong solution.

There has to be conducted an investigation of special situations. The same is to the maintenance alternatives. A "non-additiveness" measure in the space of the preferences is more realistic to be used in the problems of subjective analysis. Such measure has been proposed in [4].

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