PROBABILISTIC MEASURES OF FUZZINESS IN IMAGE DISCRIMINATION PROCESSES

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Decision making is the most important step, key element in activity of any complex system that functionsin real conditions of the environment.

The process of decision making in man is always associatead with action in the conditions of informational shortage. When the situation is clear the decision is unambiguous and automatical. The decision making problem appears only in the case of uncertainty and fuzziness.

The significant encrease in the number of psychological tasks that can be solved at present is attributed mainly to utilization of methods of the probabilities theory. However, the probabilistic methods alone are not sufficient because, firstly, as a rule we deal with uncertain incomplete knowledge of density of probabilities distribution in concrete tasks, secondly, in many practically solved tasks man encounters an uncertain situation primarily connected with indistinctness of the notions being formed and fixed in informational thesaurus of the person making a decision [1,2,3,4,5,8,9,10] .

One of the widespread and interesting examples of decision making processes in man's activity is image discrimination. Succesfully realized processes of decision making in discrimination of the image with various degree of informational uncertainty allow to follow the dynamics of the complex hierarchic process of accumulation of data on the studied image, comparison of ob-

tained information with the notion of this image kept in man's memory. For practical application of the fuzzy sets theory in studies on psychophysiological mechanisms of image discrimination it is necessary to develop and testify methods of determination of probability of fuzzy phenomena in the process of fuzzy logic of man's behaviour in a problematic situation.

In the present work has been made an attempt to calculate "fuzzy probabilities" of choice and the value of alternative actions in the process of discrimination of a vague incomplete image by man. The examinees were to distinguish an object in the process of successive representation of its characteristics. Information was given in the visualized form on 5 slides with gradually encreasing semantics/ every new slide added some characteristics of the object/. In two series of experiments the examinees were to discern two images an "arm-chair" and " a tram". As the instruction ran the formers was supposed to be associated with 5 following objects : a bed / x_1 /, a chair / x_2/, night-table / x_3/, an arm-chair / x_4/, a pier-glass / x_5 /, the latter-with 5 following items : a ship / x_1 /,,a carriage / x_2 / , a a tram / x_3 /, a trolley-bus / x_4 / , a bus / x_5/. For example in the second case in the successive slides there were : "a frame" / step I /, " a frame + a roof " /step II /, " a frame + a roof + a bar " / step III / and so on. The examinee had to evaluate the degree of resemblance of the image in question with one of the mentioned objects by means of linguistic terms / frequently used in the colloquial speech / : "may be","yes,most likely", "no, most probably", "no", "yes" and also by numerical values of subjective probability. For all the examinees the numerical values of the membership function corresponded to the linguistic

terms: "yes " -I, "no" - 0 ,"may be"-0,5,"yes,most Likely "-0,8 , "no,most prabably"-0,2 . Thus,for instance,the examinee number I at the first stage /the first slide / discribed the process of discrimination of " an arm -chair" by the following fuzzy set

$$A = \left\{ \frac{0}{x_I}, \frac{0,5}{x_2}, \frac{0,8}{x_3}, \frac{I,0}{x_4}, \frac{0,2}{x_5} \right\}$$

with the corresponding subjective probabilizies

$$p/x_I/ = 0,I\ ;\quad p/x_2/ = 0,3\ ;\quad p/x_3/ = 0,3\ ;\quad p/x_4/ = 0,3\ :$$

$$p/x_5/ = 0\ .$$

The according to L. Zadeh [9] the probability of the fuzzy event - identification of the image - is determined as

$$p/A/ = 0 \cdot 0,I + 0,5 \cdot 0,3 + 0,8 \cdot 0,3 + I,0 \cdot 0,3 + 0,2 \cdot 0 = 0,69,$$

since,as pointed out R.Yager [7,6] probability of the fuzzy phenomenon should be determined by fuzzy probability rather than by a single number,the former denoting a fuzzy subset of elements,numerical values of the membership function of which correspond to participation of the investigated phenomena in the compound fuzzy probability values we introduce the α- level sets of R.Yager [6].

$$A_\alpha = \left\{ x \in X \;\middle|\; \mu_A(x) \geq \alpha \right\},$$

where A_α - a subset of elements with the membership function larger or equal to α .

Naturally , in the case determination of the fuzzy phenomenon becomes more complete and better correspond to the nature of the fuzzy logic of image discrimination. In this case α-level sets have the form

$$A_{\alpha_1} = \left\{ x_I , x_2 , x_3 , x_4 , x_5 \right\} \qquad \text{at } \alpha \geq 0;$$

$$A_{\alpha_2} = \{x_2, x_3, x_4, x_5\} \quad \text{at } \alpha > 0;$$

$$A_{\alpha_3} = \{x_2, x_3, x_4\} \quad \text{at } \alpha \geq 0{,}2;$$

$$A_{\alpha_4} = \{x_3, x_4\} \quad \text{at } \alpha \geq 0{,}5;$$

$$A_{\alpha_5} = \{x_4\} \quad \text{at } \alpha \geq 0{,}8$$

Then respectively $p(A_\alpha)$ will be

$$p/A_{\alpha_1}/ = 1{,}0; \quad p/A_{\alpha_2}/ = 0{,}9; \quad p/A_{\alpha_3}/ = 0{,}9; \quad p/A_{\alpha_4}/ = 0{,}6;$$

$$p/A_{\alpha_5}/ = 0{,}3$$

and the total fuzzy set $p/A/$ equals

$$p/A_\alpha/ = \left\{ \frac{0}{1{,}0}, \frac{0{,}2}{0{,}9}, \frac{0{,}5}{0{,}9}, \frac{0{,}8}{0{,}6}, \frac{1{,}0}{0{,}3} \right\}.$$

Analogically we calculate the Zadeh probability and the Yager fuzzy probability at the subseqent stages of image discrimination. Table 1 shows the total results obtained on 5 examinees in the course of identification of the "arm-chair" image.

As seen from the table the process of image discrimination is accompanied by gradual encrease in the numerical value of probability /according to L. Zadeh and in the case of "fuzzy probability /according to R.Yager / there was observed the rise of the numerical value of the denominator /in the fuzzy subsets of numbers / up to the maximum value of I,0. There were some maximum value of I,0. There were some exceptions when the examinees /N 4,5 / failed to correctly distinguish the image in question. In this case the amount of probability fell as the image was represented,and in "fuzzy probability" we revealed considerable scatter of denominator values from I,0 to 0.

Similiar data were obtained in the "tram" experiments.

Table I

Dynamics the numerical values of probability and "fuzzy probability" in the process of discrimination of the vague image/"an arm-chair" /

Examinee	Stages of the experiment	Probability: p /A/	"Fuzzy probability" p /A$_\lambda$/
1	I	0,69	$\left\{\frac{0}{I,0}, \frac{0,2}{0,9}, \frac{0,5}{0,9}, \frac{0,8}{0,6}, \frac{I,0}{0,3}\right\}$
	2	0,75	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{I,0}, \frac{0,8}{0,5}, \frac{I,0}{0,5}\right\}$
	3	0,75	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{I,0}, \frac{0,8}{0,5}, \frac{I,0}{0,5}\right\}$
	4	0,80	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{I,0}, \frac{0,8}{0,6}, \frac{I,0}{0,6}\right\}$
	5	0,85	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{0,7}, \frac{0,8}{0,7}, \frac{I,0}{0,7}\right\}$
2	I	0,58	$\left\{\frac{0}{I,0}, \frac{0,2}{0,8}, \frac{0,5}{0,7}, \frac{0,8}{0,5}, \frac{I,0}{0,3}\right\}$
	2	0,7I	$\left\{\frac{0}{I,0}, \frac{0,2}{0,9}, \frac{0,5}{0,8}, \frac{0,8}{0,7}, \frac{I,0}{0,4}\right\}$
	3	0,98	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{I,0}, \frac{0,8}{I,0}, \frac{I,0}{0,9}\right\}$
	4	0,98	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{I,0}, \frac{0,8}{I,0}, \frac{I,0}{0,9}\right\}$
	5	I,0	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{I,0}, \frac{0,8}{I,0}, \frac{I,0}{I,0}\right\}$
3	I	0,65	$\left\{\frac{0}{I,0}, \frac{0,2}{0,9}, \frac{0,5}{0,8}, \frac{0,8}{0,5}, \frac{I,0}{0,4}\right\}$

2	0,50	$\left\{\frac{0}{I,0}, \frac{0,2}{0,7}, \frac{0,5}{0,6}, \frac{0,8}{0,4}, \frac{I,0}{0,3}\right\}$
3	0,65	$\left\{\frac{0}{I,0}, \frac{0,2}{0,8}, \frac{0,5}{0,7}, \frac{0,8}{0,6}, \frac{I,0}{0,5}\right\}$
4	0,75	$\left\{\frac{0}{I,0}, \frac{0,2}{0,9}, \frac{0,5}{0,8}, \frac{0,8}{0,7}, \frac{I,0}{0,6}\right\}$
5	0,95	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{I,0}, \frac{0,8}{0,9}, \frac{I,0}{0,9}\right\}$
I	0,7o	$\left\{\frac{0}{I,0}, \frac{0,2}{0,9}, \frac{0,5}{0,8}, \frac{0,8}{0,6}, \frac{I,0}{0,5}\right\}$
2	0,38	$\left\{\frac{0}{I,0}, \frac{0,2}{0,8}, \frac{0,5}{0,3}, \frac{0,8}{0,3}, \frac{I,0}{0,2}\right\}$
3	0,32	$\left\{\frac{0}{I,0}, \frac{0,2}{0,8}, \frac{0,5}{0,2}, \frac{0,8}{0,2}, \frac{I,0}{0,2}\right\}$
4	0,I8	$\left\{\frac{0}{I,0}, \frac{0,2}{0,9}, \frac{0,5}{0}, \frac{0,8}{0}, \frac{I,0}{0}\right\}$
5	0,2	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{0}, \frac{0,8}{0}, \frac{I,0}{0}\right\}$
I	0,78	$\left\{\frac{0}{I,0}, \frac{0,2}{I,0}, \frac{0,5}{0,8}, \frac{0,8}{0,7}, \frac{I,0}{0,5}\right\}$
2	0,56	$\left\{\frac{0}{I,0}, \frac{0,2}{0,7}, \frac{0,5}{0,7}, \frac{0,8}{0,5}, \frac{I,0}{0,3}\right\}$
3	0,48	$\left\{\frac{0}{I,0}, \frac{0,2}{0,5}, \frac{0,5}{0,5}, \frac{0,8}{0,5}, \frac{I,0}{0,4}\right\}$
4	0,48	$\left\{\frac{0}{I,0}, \frac{0,2}{0,5}, \frac{0,5}{0,5}, \frac{0,8}{0,5}, \frac{I,0}{0,4}\right\}$
5	0,32	$\left\{\frac{0}{I,0}, \frac{0,2}{0,4}, \frac{0,5}{0,4}, \frac{0,8}{0,4}, \frac{I,0}{0}\right\}$

The above algorithm of estimstion of probability and "fuzzy probability" may be used for predicting results of the dis-

crimination process / as one of decision making processes in conditions of informational uncertainty/. It may be also employed for formalization of psychophysiological mechanisms of man's purposeful behaviour in a problematic situation in terms of the probabilities theory . This allows to utilize the well-developed probabilities theory in psychological investigations to a great extent.

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