Pattern recognition by method of probable algorithm quantums of knowledges (PAQK-method)

I.B.Sirodzha, B.Bar, I.I. Sirodzha
State Aero-Space University
named after Zhukovsky N. Yeg. «KhAI»
61070, Kharkov, Chkalova str.,17, chair 603,
phone (0572) 44-27-34

In the difference of widely known modeling of human's brain functions, using taught **neuron nets** for pattern recognition [1,2] quantum approach [3-5] is developing for modeling human generation of cause-consequence reasoning in processes of making decisions with help of taught on examples of **logical nets of probable reasoning (LNPR).**

The method of probable algorithm quantums of knowledges (PAQK-method) is proposed for pattern recognition using **v-quantum net of decisions' output** (v-QNDO), generated during the process of teaching LNPR on the totality of **scenario examples of taught knowledges (SETK).**

So instead of finding indexes of synoptical neurons' connections with given topology of net PAQK-method provides restoring beforehand unknown topology v-QNDO and definition of probable reliability's estimations of it's v-quantums as events. Taught and optimized on abundance v-QNDO is a base of probable quantums of knowledges (BPQK) and, at the same time, mechanism of the output of recognizing decisions with counting indexes of their reliability(IR).

1.INTRODUCTION

Great requirements in working out methods of decision poorly structured and unstructured problems of pattern recognition under uncertain conditions exist[6]. Let's distinguish a class $K(\alpha)$ of problems connected with α-undefinition, that slipulates for probable character, variety of types, uncompleteness, careless of initial information, with unknown informational signs and deciding rules, alternative and formal purposal criterions , and also with demand in knowledges of experts in concrete subject field.

The peculiarity of suggested PAQK-method of recognition concludes in attracting for outputing finding rules of making recognition decisions not only digital data of measurings and observations but portions (quantums) of knowledges of specialists in given subject field in the form of probable saying and cause-consequence conclusions of productional character, that have relations with finding decisions. With it using PAQK-method the task of indivisible formalization, presenting and algorithm manipulating of digital and lingvistic information in the form of variety of levels on complication **probable algorithm quantums of knowledges (vk-knowledges)** using vector-matrix operators is decided.

In the difference from traditional presenting teaching LNPR makes with given SETK and consists in definition of parameters net's vk-knowledges-knots, their quantity and cause-consequence connections between them. Teaching is finished when **structured completeness v-QNDO** is achieved, that is when equivalent count G, that has numeral function [7], which last level of summits keep only purpose v-quantums-conclusions, corresponds to the net.

Substantially it means, that with structured completeness v-QNDO admission of net's knots and logical connections between them, and from any v-quantum-knot exists way to any purpose v-quantum-consequence, is found.

So in structure completed v-QNDO **input** knots correspond to sending v-quantums of initial signs OMD or facts, **output** – v–quantums of purpose conclusions, and inside knots – v–quantums of intermediate confirmations or partial decisions.

Peculiarity vk–knowledges is in presence inbuild procedures for realization of exact countings of intermediate and concluding decisions' probables on the base of equivalent transformations of logical functions statisticallly depended v–quantums chains to independent by ortogonizating of corresponding logical functions .

2. ORGANIZATION OF THE TASK

It is necessary to decide two basic tasks of formaly presenting different-levels vk-knowledges (A_V**–task)** and algorithm synthesis of the rule of

making recognition decisions on the base of using vk–knowledges (B_v **–task).**

Formally A_v –task for vk–knowledges let's present as multitude five

$$A_v = \langle S_v, K_v, \tilde{V}, \Pi_v, Q_v \rangle, \quad (1)$$

where S_v – symbol language v–quantums of knowledges, that consists of final multitude of letters, digits and symbols of the algorithm theory's operations;

K_v – final multitude of terminal v–quantums of knowledges ; set before experiment;

$\tilde{V}$ – probable multitude, that birth meanings a function $p_v(\bullet)$ of events reliable, described by different-levels v–quantums, that is multitude of indexes of reliability of vk–knowledges from the interval [0, 1];

Π_v – rules of designing of different-levels v–quantums;

Q_v – multitude of semantically codes and special structures of data, that determine level and maintenance v–quantums structures of knowledges with algoritmization.

In other words, in A_v –task it is necessary to create the formal mechanism of building class M_v of different-levels vk–knowledges in the language S with meanings of reliabiliti's degree from $\tilde{V}$ on the base of using rules Π_v to terminal v–quantums from K_v, and also with needed level and contents of v–quantums with corresponded semantic codes from Q_v.

Probable multitude $\tilde{V}$ on universal multitude U={u} is called totality of pairs of such type

$$\tilde{V} = \{\langle u \mid p_v(u) \rangle\}, \quad (2)$$

where $p_v(u): U \to [0,1]$.

Showed reflection U to segment [0, 1] we'll call **function of reliability** $p_v(u)$ probable multitude $\tilde{V}$, and meaning p(u) for concrete element $u \in U$ – **index of reliability** (IR) p(u) value u.

Different-**types characteristic** of the object of recognition (OR) in examples cause-consequence sayings of experts or judgment about outputing finding decisions with some appraisal of their probable from other sources, and also **quantity** and **ccontents requirements conclusions at the form SETK** in decided B_v –task from concrete subject field are given.

It is necessary to work out total method of algorithm decision of B_v –task, and also to synthesis and ground in terms of PAQK-method necessary basic algorithms: teaching LNPR (ALOBUCH), automatic quantuming (ALAKVA), optimization of the net (ALAKVA) , outputing recognition rule (AL(B_v)) and management of functioning v–QNDO (ALUPR).

3. METHOD OF DECISION A_v –, B_v –TASKS

Method of decision A_v –task is based on theoretic positions, given in works [3-6, 8], with using operators superposition (**P–operator**), line operator of concatenation (**CON <•> –operator**) and column (**CON[•] –operator**), and also new terminal v–quantums from multitude

$$K_v = \{vk_0a, vk_1y, vk_1b\}. \quad (3)$$

Here **terminal choosing v-quantum of knowledges of the nil level** vk_0a **with semantic**: «from ℓ-measured totality observed probable meanings of signs $\alpha_1, \alpha_2, \ldots, \alpha_\ell$ to choose meaning α_k with reliable's index $p(\alpha_k) \in [0,1]$»
has such form:

$$vk_0a = [V_k^{(\ell)}(\alpha_1 \mid p(\alpha_1), \ldots, \alpha_k \mid p(\alpha_k), \ldots, \alpha_\ell \mid p(\alpha_\ell)) = \alpha_k \mid p(\alpha_k)], \quad (4)$$

where $vk_0 \in Q_v$, a , $V_k^{(\ell)} \in S_v$.

Terminal vector v–quantum of knowledges of the first level vk_1y with semantic : «observed OR $y \in \Omega$ j, has n different-types sings $x_j, (j = \overline{1,n})$, which meanings $\alpha_{k_j}^j \in \tilde{X}^j, (k_j = \overline{1, r_j})$ with correspondence IR $p(\alpha_{k_j}^j) \in [0,1]$» has a form

$$vk_1y = [d_1^{x_1} : d_2^{x_2} : \ldots : d_n^{x_n}] = [\alpha_1^1 \mid p(\alpha_1^1), \ldots, \alpha_{r_1}^1 \mid p(\alpha_{r_1}^1) : \alpha_1^2 \mid p(\alpha_1^2), \ldots, \alpha_{r_2}^2 \mid p(\alpha_{r_2}^2) : \ldots : \alpha_1^n \mid p(\alpha_1^n), \ldots, \alpha_{r_n}^n \mid p(\alpha_{r_n}^n)], \quad (5)$$

where $vk_1 \in Q_v$ name $y \in S_v$; $\alpha_i^j \mid p(\alpha_{r_i}^j) \in \tilde{V}$.

Terminal characteristic v–quantum of the first level vk_1b with the name b has a form

$$vk_1b = [\chi_{\tilde{Y}_j}(\alpha_k^j \mid p(\alpha_k^j))] = \begin{cases} 1, \text{if } \alpha_k^j \mid p(\alpha_k^j) \in \tilde{Y}_j, \\ 0, \text{if } \alpha_k^j \mid p(\alpha_k^j) \notin \tilde{Y}_j, \end{cases} \quad (6)$$

where $\tilde{Y}_j = \{\alpha_k^j\}$ - fixed probable multitude k's meanings j's sing, $vk_1 \in Q_v, b, \chi_{\tilde{Y}_j} \in S_v$ with **semantic**:

«meaning α_k^j j's sign OR in given moment is fixed by observing with IR $p(\alpha_k^j)$, if meaning of characteristic function $\chi_{\tilde{Y}_j}=1$; otherwise if $\chi_{\tilde{Y}_j}=0$ the result of observing are ignored as doubtful».

Definition 1. Algorithmic constructions, got from components of the multitude K_v (3) by final quantity of using to them P–operator, CON⟨•⟩–operator and CON[•]–operator in frameworks A_v–task (1), are called different-levels vk–knowledges. Class vk–knowledges M_v, made on definition1 1,let's call **standard class PAQK–models of** presenting of knowledges about object under recognition (OR).

For example, by expression

$$vk_1cl=$$

$$=[\overbrace{0,1|p(\alpha_2^1),1|p(\alpha_3^1),\varnothing:}^{x_1}\overbrace{1|p(\alpha_1^2),0,\varnothing:\varnothing|\varnothing:}^{x_2}\overbrace{\alpha_1^{3u}|p(\alpha_1^{3u}),\varnothing:}^{x_3=x_u}$$

$$\underbrace{:p(\to cl);A(cl)p(cl)}_{\text{output domain}}$$

(7)

is presented widen vector v-quantum of knowledges of the first level with name of purposed consequence c1 on purposed sign x_u, correspondence to three components sending sign x_1 and two components sign x_2 OR.

Semantic vk_1c1 (7) is: «**IF** observing the second knowledge α_2^1 sign x_1 with IR $p(\alpha_2^1)$ **OR** third knowledges α_3^1 with OR $p(\alpha_3^1)$ **AND** first meaning α_1^2 of sign x_2 **THEN** OR has one component purposed sign x_u with IR $p(\alpha_u^n)$; with it output IR p(cl) v–quantum is counted by algorithm A(cl), using set probability $p(\to cl)$ of implication, that is probability of joint making consequence c1 with sendings $\alpha_2^1|p(\alpha_2^1)$ **OR** $\alpha_3^1|p(\alpha_3^1)$ **AND** $\alpha_1^2|p(\alpha_1^2)$» for given v-quantum in multitude Q_v contended correspondent program and structure of data, that realize set sence and execution of the algorithm A(cl).

Inputed class M_v vk–knowledges has multitude present at the form of N–measured space $\tilde{X}^{(N)}$ PAQK–models. It guaranties comfortable for computer formalization of knowledges about decided rules, events and conformities to natural lows of the subject field by means of vector-matrix (look. view (7)) and analytical final-predicate presents[3-5].

The method of decision of B_v–task is based on definitions 2 and 3, and also on worked out algorithms ALOBUCH, ALAKVA, ALAKVA, $AL(B_v)$ and ALUPR

Definition 2. Teaching LNPR is called orientated count $G=(E,\Gamma)$, synthesis on given SETK using algorithm ALOBUCH and **had numeral function** $\Pi(X_i)$ $\forall X_i\in E$, determined on submultitudes-levels $N_1,N_2,\ldots,N_k\subset E$ of summits, and also next **properties**:

1) all summits (knots of the net) $X_i\in E,(1\le i\le n)$ correspond to sayings from SETK of concrete subject field, and **arcs** from $\Gamma: E\to E$ show on cause-consequence connections between knots with logical connections «AND», «OR», «NOT»;

2) all knots $X_i\in N_1\subset E$ with $\Gamma^{-1}N_1=\varnothing$ correspondent **output sending information** $e_i,(1\le i\le n_n)$ relatively some consequences $c_j,(1\le j\le m_c)$ with given IR $p(e_i)$ and $p(\to c_j)$;

3) all knots $X_i\in N_k\subset E$ with $\Gamma N_k=\varnothing$ are **purposing** (output) knots-conclusions C_s, $(1\le s\le S)$ with counted IR $p(C_s)$, and all summits intermediate levels between N_1 and N_k correspond to **partial consequence** c_j.

Syntheses LNPR at the mode of teaching has to be transformed in v–QNDO with help of special algorithm ALAKVA, that automatically determine **not given beforehand** quantity v–quantum **unknown beforehand levels** on **given rules** and **known knots of the** concrete levels of numeral function $\Pi(X_i)$ of the count G.

Definition 3. Purpose-oriented v-QNDO is called the result of count's transformation $G=(E,\Gamma)$ using algorithm ALAKVA to the count $G_{vk}=(E_{vk},\Gamma_{vk})$, that has following properties:

1) all summits $X_i\in E_{vk}$ correspond generated different-levels v-quantums, contended SETK of concrete subject field, and arcs $u_{ij}\in\Gamma_{vk}$ show at the logical connections v-quantums events;

2) all $X_i\in N_1\subset E_{vk},\Gamma^{-1}N_1=\varnothing$ correspond to **input vk-knowledges-sendings** with names $e_i,(1\le i\le n_n')$ relatively **vk-knowledges-consequences** with names $C_j,(1\le j\le m_c')$ with given indexis of reliability;

3) all $X_i\in N_k\subset E_{vk},\Gamma N_k=\varnothing$ are **purpose vk-knowledges-conclusionsи** with names и $C_s,(1\le s\le S)$ and counted IR $p(C_s)$, and all intermediate summits of

count G_{vk} corresponds to **partial vk-knowledges-consequences.**

Generated v–QNDO is optimized on criterion of abundance with the help of algorithm ALOPT and with management of algorithm ALUPR directly is used for outputing recognition decisions with counting correspondence probable appraisals of IR.

Peculiarity of manipulating vk-knowledges at the process of building and making decision by v-QNDO is **new way** of not approximate, but exactly **definition of probable appraisals** intermediate and purpose v–quantums conclusions.

It realized on the base of **ortogonalization** of logical functions, described connections between v–quantums events (sayings). With it the logic of sayings in v-QNDO is presented inпредставляется в **orthogonal dizunctional normal form**(ODNF).

Counting of meanings of these probabilities by ODNF is make by setting instead of its variables corresponded known probabilities with changing operations of logical multiplication and adding by analog arithmetic operators.

It is grounded like this. Let any event **e**:=«object $\omega \in \Omega$ has sign x» is made with probability $p(e)$, and event **c**:=«if ω ohas sign x, that ω corresponds to category **A**» is set with conditional probability $p(e \to c)$, that is called **probability of implication.** Then probability $P(e \wedge c)$ setting events at the same time **e** and **c** (as other event **z**) is determined by correlation

$$p(z) = P(e \wedge c) = p(e) \cdot p(e \to c). \qquad (8)$$

If now for showed events **e** and **c** to correspond logical variables α and β correlatively, then the probability **p(z)** (8) could be counted as probability of logical conjunction $\alpha \bullet \beta$ to be true meaning «1» on the any admission of meanings of its variables α and β with giving probabilities of appearing their true meanings.

For more complicated event **z1:=** «**if** object ω has sign x_1 **or** x_2, **or** ... **or** sign x_k, **then** ω belongs to class **A**» probability **p(z1)** can be counted on logical function $\alpha_1 \cdot \beta_1 \vee \alpha_2 \cdot \beta_2 \vee \ldots \vee \alpha_k \cdot \beta_k$, transformed to equivalent to it ODNF

$$\alpha_1\beta_1 \vee \overline{\alpha_1\beta_1} \cdot \alpha_2\beta_2 \vee \overline{\alpha_1\beta_1} \cdot \overline{\alpha_2\beta_2} \cdot \alpha_3\beta_3 \vee \ldots$$
$$\ldots \vee \overline{\alpha_1\beta_1} \cdots \overline{\alpha_{k-1}\beta_{k-1}} \cdot \alpha_k\beta_k.$$

At the result of deducting outputing **probable identified decisions** relatively OR ω with given sending vk–knowledges $vk_1Y_{B\omega}$ in B_v–task with help of algorithm АЛ(B_v) at the output v–QNDO purpose vk–knowledges are formed $vk_sR_{B\omega}, (s = 0,1)$ as one or some v–quantums with counted resulted IR $p(R_{B\omega})$. Semantic $vk_sR_{B\omega}$ shows at the **belonging identified OR** ω to definition category or **class** K from Ω with given reliability.

Let while decision B_v–task are used classified **SETK**(B_v) and at the result of studying was got correspondence v–QNDO as functional BPQK(B_v) for **recognition** (identification) of **situation** in conditions α–undefinition using IND–operator [3-4] as

$$BPQK(B_v) = \text{SETK}(B_v) \xrightarrow[\text{ALOBUCH,ALAKVA,ALOPT}]{\text{IND}} \text{BPQK} \qquad (9)$$

Then formally algorithm decision B_v–task concludes in getting purpose vk–knowledges $vk_sR_{B\omega}$ by DED–operator [3] as

$$vk_s \; R_{B\omega} = \text{DED}(\text{BPQK}(B_v), vk_1Y_{C\omega}; \text{AL}(B_v), \text{ALUPR}, vk_sR_{B\omega}):$$
$$= BPQK(B_v) \xrightarrow[vk_1Y_{B\omega}; \text{AL}(B_v), \text{ALUPR}]{\text{DED}} vk_sR_{B\omega}. \qquad (10)$$

Consequently, IND- and DED-operators are realized by algorithms, showed under the pointer in (9) and (10) formulas.

4. SOFTWARE AND EXPERIMENTAL INVESTIGATION OF PAQK-METHOD.

On the base of using adduced method in p. 3 interactive program complex (IPK) «V–KVANT» was created as investigational prototype intellectual (SSMD) on the base of using PC. Total architecture of IPK is presented on p. 1.

IPK successfully was tested during experimental decision of series tests and real tasks of patterns recognition.

Software «V–KVANT» is a kernel of new informational technology of knowledges' engineering, based on PAQK–method.

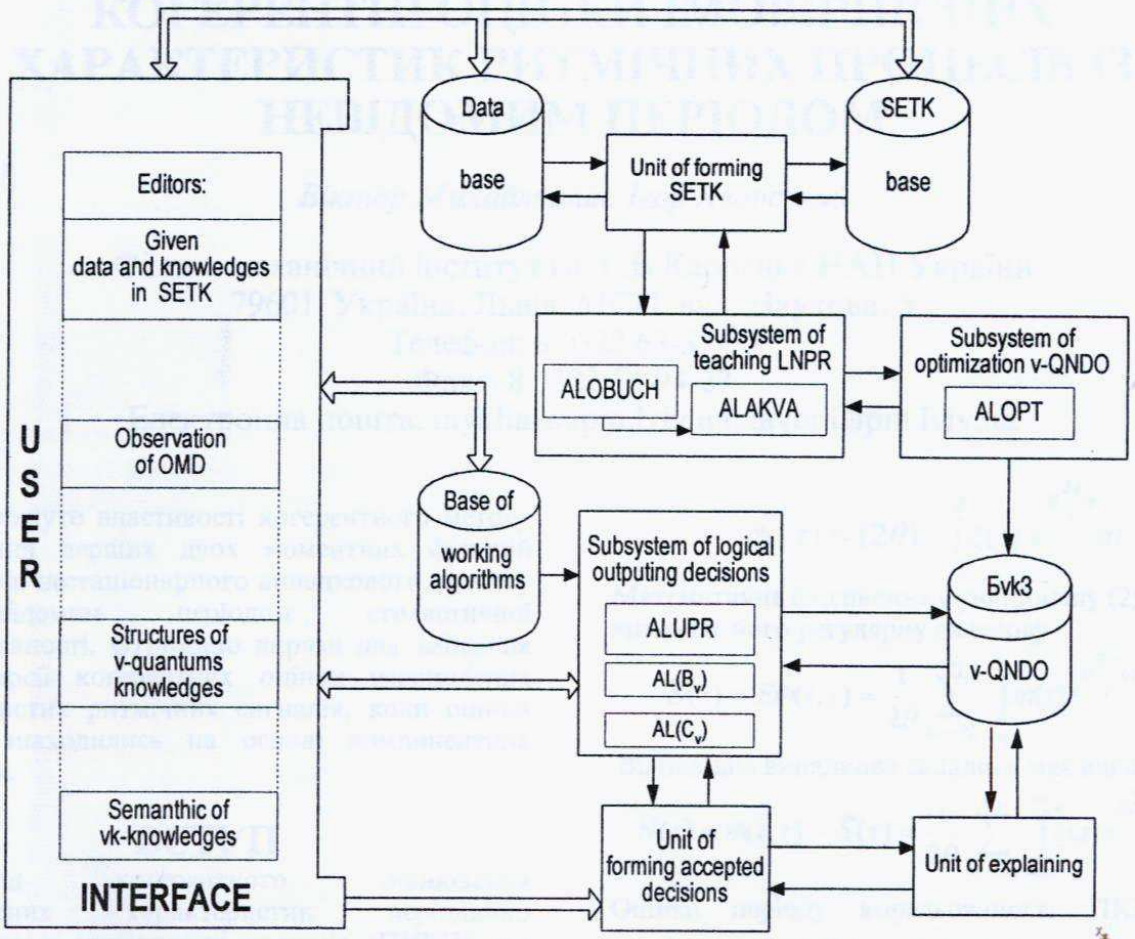

Fig. 1. Total architecture of IPK "V-KVANT"

CONCLUSION.

New PAQK–method of patterns recognition is worked out, on the base using which acting IPK «V–KVANT» was worked out for decision productional tasks of supporting making recognition and prognosing decisions. The results of experimental appraisal and comparement with other methods showed high level, affectivities and advanteges of PAQK–method. The last one conclude in decreasing average risk of recognition on the order, increasing speed of action of the teaching process in 2.5 times and decreasing volume of using memory on BPQK in 1,5 times.

LITERATURE

1. Уоссермен Ф. Нейрокомпьютерная техника: Теория и практика. – М.: Мир. –1992. –240с.

2. Горбань А. Н. Обучение нейронных сетей. – М.: СП Пара Граф.–1990. –160с.

3. Сіроджа І.Б. Знанняорієнтований підхід до проблеми розпізнавання образів // Праці Третьої Всеукраїнської Міжнародної конференції "Оброблення сигналів і зображень та розпізнавання образів" (УкрОбраз'96). – Київ.: Кіб. центр НАН України.–1996.– С. 30-33.

4. Сіроджа І.Б. Розпізнавання образів методом різнорівневих алгорітмічних квантів знань // Праці Четвертої Всеукраїнської Міжнародної конференції "Оброблення сигналів і зображень та розпізннавання образів" (УкрОбраз'98). – Київ.: Кіб. центр НАН України.–1998.– С. 17-19.

5. Сироджа И.Б. Квантовый подход к решению задач инженерии знаний // Проблемы бионики. – 1999.– Вып. 50. – С. 35-42.

6. Ларичев О.Н., Мошкович Е.М. Качественные методы принятия решений. – М.: Наук, Физмат.– 1996.–208с.

7. Кофман А. Введение в прикладную комбинаторику.–М.: Наука, 1975. – 480с.

8. Сироджа И.Б., Петренко Т.Ю. Квантовые модели нечетких знаний для принятия приближенных решений при недостатке данных // Проблемы бионики.– Харьков, 1998.– №48 – С. 129–140.