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COMPARISON DISCRIMINATE CHARACTERISTICS BETWEEN MODERN TNDA-PRH RHINOMANOMETER AND PREVIOUSLY METHODOLOGY

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ABSTRACT

This method can be considered as respect to the improvement information-measurement technology alternative control and technical diagnostics. This method allows planning multiple repeated measurement groups, obtained on the basis of non-stationary measurement signals with priori unknown spectral properties. By using the method of piecewise-linear regression approximation of measuring signals allowed obtaining additional information about the changes in random coefficients' partial linear regression . Proposed comparison of discriminate characteristics of rhinomanometry diagnostic methods for our proposed computer KPM type TNDA-PRH rhino manometer and previously methodology, using the Mahalanobis distance were used to measure the distance between the random vectors of values and generalize the concept of Euclidean distance. Experiments prove that, the proposed method in our work of rhinomanometry measurement at forced respiration has great (1.4 factor) discriminate features in comparison with traditional methods and reduces the possibility of errors when making decisions of diagnostic solutions from 0.17 to 0.06. Also the factor of time displacement between the amplitudes of the pressure signals, which had not been taken into consideration previously, which playing an important role in the diagnosis. that allows the use of this method for objective functional diagnostics of the upper respiratory tract. This work aims to develop methods and criteria that allow the differential diagnosis for pathologies of the upper respiratory tract according to rhinomanometry data.

KEYWORDS: Rhinomanometric Diagnosis AARM and APRM, Norms and Disorders of Nasal Breathing, Pressure Drop, Air Flow Rate, Static Model, Dynamic Model, Multichannel Measurement Module, Discrimination, Object Control, Discriminate Characteristics, Uncertain Object Characteristics, Uncertainty Conditions, Errors Possibility ,Controlling Objects States, Probability of Making Correct Decision, Mahalanobis Distance, The Factor of Time

BACKGROUND

Methodology of Rhinomanometry

The principles applied during the past few decades for measuring the relationship between pressure difference and airflow volume through the nose can be described as follows:

External Airflow Methods (Passive Rhinomanometry)

External airflow methods consist of pumping a constant, predefined amount of air through a nasal olive into or out of the nose. The resultant pressure difference generated can thus be measured. The basis of this method, so called "passive rhinomanometry", can be traced to Kayser [1] in 1895, and it has been used in children, especially when active rhinomanometry testing was not possible [2]. Passive rhinomanometry had been the only available method used to study nasal ventilatory functions until the development of pneumotachography [2.3]. The passive rhinomanometry has several critical drawbacks that one should be aware when using this procedure, or when analysing and comparing data.

Spontaneous Flow Method (Active Rhinomanometry)

Due to the drawbacks of external flow methods above[4], a general consensus has been reached worldwide that the patient's own physiological airflow should be used for assessing nasal ventilatory functions whenever possible. Not only the natural dynamics of nasal breathing can be measured, but nasal symptoms can also be correlated to the pulmonary physiological parameters. According to Semarak [5], these methods can even be traced to Brünings [6] and have been mentioned in the description summarized by Zwaardemaker [7]. In 1958, Semarak [5] described the first "Nasal Patency Assessment Device" that enabled simultaneous assessment of nasal respiratory flow and pressure difference between the nasal entrance and choanae.

Rapid development of microelectronics within last two decades has not only made space flight possible, but it has also ensured that digital measuring technologies, originally possible only using large mainframe computers, have found their way into many areas of everyday life. In rhinomanometry, this particularly pertains to the accurate measurement of very low pressures and flow rates. Thus, new pathways have opened up in rhinology for the implementation of precise and manageable measurement technologies, which can be readapted to suit the needs of practical medicine. Active Rhinomanometry distinguishes in turn between two measurement techniques after deriving the pressure difference between nasal entrance and choanae: the anterior and posterior methods. Active Anterior Rhinomanometry (AAR) involves closing one nostril with a measuring pressure probe, the other nostril thereby serving as an extension of the probe, while Active Posterior Rhinomanometry (APR) measures pressure difference via a tube in the mouth, with or without a mouthpiece, and held by the lips. In order to accurately measure total nasal resistance by APR, the soft palate and the tongue must be relaxed. Since pressure is deflected by the soft palate, the resistance of the anatomical structures between the oropharynx and choanae become effective in addition to the nasal resistance. Thus, rhinomanometric results obtained by AAR and APR are not always comparable. Typical examples for such differences are found in children with enlarged adenoids, in cleft palate patients and patients with nasopharyngeal fibromas or choanal polyps.

INTRODUCTION

In recent decades, a significant increase in prevalence of upper respiratory tract diseases has been recorded. One of the leading places of which is the pathology of the nose and paranasal sinuses, According to data [1] in Ukraine, more than 10% of the population suffer from chronic inflammation of the paranasal sinuses—sinusitis. Upper respiratory tract diseases, which most often begin with a disturbed respiratory function of the nose, result in reducing the life quality of patients and may lead to cardiovascular diseases and disorders of the central nervous system. The effectiveness of therapy in this case essentially depends on the quality of the diagnosis and choosing the appropriate treatment strategy [8].

THE ACTUALITY OF THE TASK

In studying the most significant functions of the upper respiratory tract, the rhinomanometric method, which involves measuring the pressure drop on the nasal passages and the corresponding air flow rate during breathing, is used [9]. At present, a large number of methods and tools for rhinomanometric diagnosis can be utilized. However, the anatomical features of the upper respiratory tract had complex physiological process of breathing and lack actual standards, leading to the fact that the evaluation of the nasal region, which characterizes the degree of respiratory failure, essentially depends on the method of measurement and has significant variability. Therefore, the actual problem is to expand the diagnostic capabilities of investigation methods and substantiation expediency of application of these methods in the diagnosis of specific pathologies. Our study is pointed out, that the key parameters are not only intranasal pressure and flow, but also the factor time. Some measurements performed by our method as following from the dynamics of breathing are described.

STATEMENT OF THE PROBLEM

During the development of computerized rhinomanometry, it was necessary to consider how pressure and flow vary during a breathing cycle. We had to analyze the dynamics of both measurement channels and to eradicate methodical errors. It became apparent, that another factor played a significant role: this factor was time, which had not been taken into consideration previously. Time is an important physiological factor, because it is essential that the amount of oxygen required by the body reach the lung within a period corresponding to its oxygen needs. In cases of elevated nasal obstruction, this time limit is exceeded and mouth breathing becomes necessary. For example, during vigorous exercise or physical work, this transition is physiologically predetermined. However, when a person at rest feels compelled to breathe through the mouth, this indicates that sufficient amounts of conditioned air cannot flow under those conditions through the nose. Therefore, the pressure difference between the nasal opening and the epipharynx has to be maintained for a longer period to allow the transport of sufficient oxygen to the lungs. Therefore, the diagnostic aim of computer KPM type TNDA-PRH -rhinomanometry is to measure the intranasal pressure, flow and time variables necessary for maintaining an adequate oxygen supply through the nose.

As well as when developing new diagnostic methods and tools, the final step is to compare the discriminate characteristics of the proposed method with the existing ones. In this case, an important task is to select the informative parameters of diagnosis and control, as well as the criterion by which the discriminate features of the methods will be compared. Effective solution of the task of controlling objects states with random properties depends on the correct choice of the maximum informative system parameters (signs) and sensitivity to changes in the characteristics of the object. Any formal control implements the procedures of testing; resulting effectiveness, which determined certainty; and the probability of making the correct decision [10]. Under uncertain object characteristics, the task of selecting informative parameters becomes problematic, especially if complicated metrological support informational transformation in the structure of the system control.

LITERATURE ANALYSIS

Selection of an optimal, by criterion of the maximum certainty, Information System signs- this is classical mission for statistical synthesis under a priori uncertainty conditions [11,12,13]. Ranking signs on information performed again by the accuracy of control parameters value [14] or errors possibility. [15]

THE PURPOSE OF WORK

This study aims to demonstrate the possibility of using criteria parametric models for identification (discrimination) when comparing diagnostic possibilities of using the rhinomanometric method.

THE MAIN PRINCIPLES OF DIAGNOSTIC RHINOMANOMETRY

In modern times, rhinomanometry is performed using specialized computer rhinomanometers, allowing the use of automated or semiautomatic modes, to determine the parameters of nasal breathing and carry out a graphic visualization of measurement results [9]. In this case, the classical method of measuring is considered as an active anterior rhinomanometry (AARM) method, performed during quiet breathing and with analysis flow rate data at a fixed pressure drop (300 Pa). The proposed method is active posterior rhinomanometry (APRM), whereas forced respiration allows the estimation of the function of the nasal valve and retrieval of information about specific values of pressure drop and air flow rate, which are very important for sports medicine. Comparison of diagnostic methods has been made on the otorhinolaryngological database of a department in Kharkiv Regional Hospital with the developed device for measuring fall casting-flow rate characteristic of computer KPM type TNDA-PRH (Certificate of state metrological attestation № 05-0102 in 01.04.2010 year). In terms of the composition of this device(as shown in fig.1) included in measuring the unit, containing a differential sensor for pressure dropping between the exit of the nasal cavity and atmospheric, and air flow rate sensor, for air passing through the nasal passages during the breathing process. The latter is based on the principle of the Venturi meter [16]. The signals coming from the sensors arrive and converted into a unit, implemented on the basis a multichannel measurement module L–Card E14–140, the main components of which are steward microcontroller AVR AtMega8515, 14-bit analog-to-digital converter(analog-to-digital converter, ADC) LTC1416 and interface module PDIUSB12D for communication of IBM PC via USB port. The digitized signals from the pressure sensor and flow rate with a sampling frequency of 500 Hz transmitted through the USB interface to the IBM PC for further processing and analysis. The main diagnostic index of the degree of disturbance in nasal breathing at the standard rhinomanometer is considered the coefficient of the generalized rate of nasal resistance, K_R

$$K_R = \frac{\Delta P}{Q}, \ \frac{\kappa \Pi a}{\text{л/с}},$$

which is considered the ratio of measured values (pressure drop ΔP to air flow rate Q). However, when taking into account the coefficient of the generalized assessment of nasal resistance, while determining the discriminate of the properties of the diagnostic methods, additional information does not matter (because it is just the attitude of the measured values), and analysis will be subject directly to distribution of measured parameters: pressure drop and flow rate.

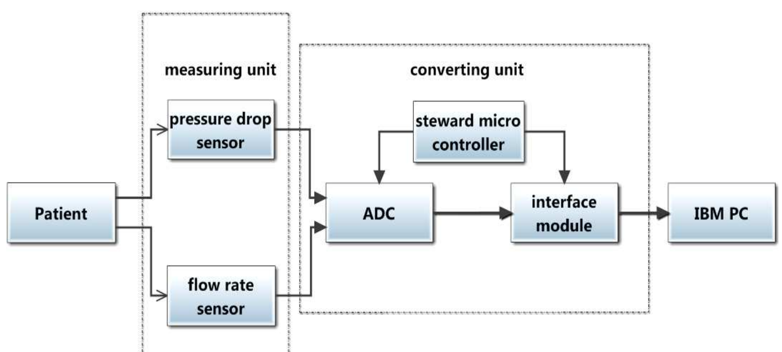

Figure 1: Schematic Diagram of the TNDA-PRH Device

MODEL OF LINEAR DISCRIMINATION

Informative parameter X is used to obtain information about a priori undetermined object control properties and can be considered as a random value. The last, in the case of two object states (Θ_0 - norm, Θ_1 - disturbance norm) is characterized by a condition of probability density distribution

$$X \approx f(X/\Theta_0), \ \text{если} \ \Theta \in \Theta_0,$$
$$X \approx f(X/\Theta_1), \ \text{если} \ \Theta \in \Theta_1.$$

If $m^{(0)}, m^{(1)}, \sigma^{(0)^2}, \sigma^{(1)^2}$ are the average and dispersion values X for conditions $\Theta \in \Theta_0$ and $\Theta \in \Theta_1$, respectively, then under Gaussian distributions $f(X/\Theta_0)$, $f(X/\Theta_1)$, error probability of decision making in the form of an object state is determined at $\sigma^{(0)^2} = \sigma^{(1)^2}$, through the probability integral $\Phi(\cdot)$ [17]

$$P_{error} = 1 - \Phi(\delta / 2) \qquad (1)$$

where $\delta = \left| \dfrac{m^{(0)} - m^{(1)}}{\sigma} \right|$ (2)

if ${\sigma^{(0)}}^2 \neq {\sigma^{(1)}}^2$, then the lower bound for the maximum square deviation of two P_{error} can be estimated by the inequality

$$P_{error} \geq 1 - \Phi(\delta / 2). \qquad (3)$$

With multiparameter control, when the number of informative parameters $X_1,...,X_n$ more than one ($n \geq 2$) variable δ in expression (1) or (3) described by the following equation:

$$\delta = \sqrt{\sum_{i=1}^{n} \left(\frac{m_i^{(0)} - m_i^{(1)}}{\sigma_i} \right)^2} \qquad (4)$$

The square of this variable

$$\delta^2 = \sum_{i=1}^{n} \left(\frac{m_i^{(0)} - m_i^{(1)}}{\sigma_i} \right)^2$$

Is called "Mahalanobis distance," the quadratic distance between the controlled conditions (between the averages vectors on states Θ_0 and Θ_1) [11].

The control object in this case is the vector column of the measured values

$$\bar{x} = \begin{vmatrix} x_1 \\ x_2 \\ . \\ . \\ . \\ x_n \end{vmatrix}$$

with conditional n- volumetric normal density distribution.

$$f(\bar{x} / \Theta_k) = (2\pi)^{-\frac{n}{2}} |\Sigma|^{-\frac{1}{2}} \exp\left[-\frac{1}{2} \left(\bar{x} - \overline{m}^{(k)} \right) \Sigma^{-1} (\bar{x} - \overline{m}^{(k)}) \right] \qquad (5)$$

In equation (5), mean vector $\overline{m}^{(k)}$ and dispersion matrix Σ have the form (k -number of the object state, $k = \overline{0,1}$):

$$\overline{m}^{(k)} = \begin{vmatrix} m_1^{(k)} \\ m_2^{(k)} \\ . \\ . \\ . \\ m_n^{(k)} \end{vmatrix}, \quad \Sigma = \begin{vmatrix} {\sigma_1}^2 & & & & & \\ & {\sigma_2}^2 & & & & \\ & & . & & & \\ & & & . & & \\ & & & & . & \\ & & & & & {\sigma_n}^2 \end{vmatrix}.$$

Expression (4) presupposes the mutual independent vector components in the linear model of discrimination. [18]

The error probability decreased. Then, the bigger δ, the greater the normalization by dispersion squared distance between average vectors. Thus, variable δ (or δ^2) by the expression (4) allow the quantitative comparison using the discriminating ability (in fact, by information) not only by a single informative signal but by a subset of (system) signals.

THE PRACTICAL APPLICATION OF THE DISCRIMINATION MODEL

Let us consider the task of effectiveness in assessing two methods of rhinomanometry: method M_a with measurements during quiet breathing and method $M_б$ with measurements in a forced breathing, allowing to obtain the measurement information about the diagnostic status of the object represented:

- a static model (method M_a rhinomanometry during quiet breathing), and
- dynamic model (method $M_б$ rhinomanometry during forced respiration).

In method M_a during quiet breathing, measured physical values (X_1—pressure drop ΔP and X_2—air flow rate Q; the number of measured parameters $n=2$), as opposed to method $M_б$, are not correlated to the duration of the observation period. State conditional norms and disorders of nasal breathing are denoted Θ_0 и Θ_1, respectively, in all the examined 60 patients, divided into two groups of 30 men: those with normal breathing and those with difficulty in nasal breathing. The measurements for each patient were carried out using the two methods (during quiet M_a and forced $M_б$ inspiration) for ten breaths. In this case and by the general algorithm for each method, the maximum pressure drop ΔP and air flow Q of the upper respiratory tract of patients in each cycle of breath were calculated and were carried out by averaging the ten breaths. Afterward, the statistical parameters for each group of patients were determined: average values $m_1^{(0)} = \overline{\Delta P}$, $m_2^{(0)} = \overline{Q}$, $m_1^{(1)} = \overline{\Delta P}$, and $m_2^{(1)} = \overline{Q}$, respectively, in normal and inappropriate nasal breathing, as well as mean square deviations of the corresponding indexes. Moreover, for calculations, the maximum value of the mean square deviations was selected: $\sigma_1 = \max(\sigma_{\Delta P}{}^{(0)}, \sigma_{\Delta P}{}^{(1)})$ and $\sigma_2 = \max(\sigma_Q{}^{(0)}, \sigma_Q{}^{(1)})$, respectively. Furthermore, according to the entered designations, calculations of the Mahalanobis distance by formula (4) and errors probability for decision making by formula (3) for each method were performed. Results are presented in Table 1.

Table 1: Results of Diagnosis Measurement Status for Method a) and b)

Type of Method	Traditional Method M_a		Proposed Method $M_б$	
Status / Parameter	Θ_0	Θ_1	Θ_0	Θ_1
$\overline{\Delta P}$, KPa	0,30	0,3	8,7	16,5
$\sigma_{\Delta P}$:	0,07	0,07	2,25	2,70
$\overline{Q}$, L/S	0,40	0,2	3,10	0,80
σ_Q : L/S	0,07	0,05	0,95	0,43
δ	2,77		3,78	
P_{error}	≤0,17		≤0,06	

FACTOR OF TIME DEPENDENCE

The phase difference between the signals of the air flow rate and the pressure drop in the nasal cavity during the breathing process, determined by a method of the dynamic Active Anterior Rhinomanometry (AAR), which studying the parameters of the nasal resistance during the respiratory cycle (in dynamics). The air velocity is measured by using , Active Posterior Rhinomanometry(APR) computer KPM type TNDA-PRH (developed by authors), were given by experimental data obtained with computer rhinomanometry to receive air flow rate. Further carried out spiral computer tomography to determine the cross-sectional area of nasal passages. By divide the flow rate into cross-sectional area we obtain the speed in each section, or the average values - as we like. (Figure.2) is a diagram for one of respiratory maneuvers, obtained by the developed device TNDA-RMP [19].

The device in the inspiratory cycle (during inspiration) fixes the flow rate at pressure drop using flow meter type venturi (sensor p1) and pressure drop (sensor p2) between the atmospheric and nasopharyngeal (at the output of Choana) in a cycle of the inspiration cycle ,(sensor P3 is used to indicate the expiration cycle and is not involved in measurement of nasal resistance).

In this case, the time displacement Δt (see Fig.2) between the maximum pressure drop signal (sensor p2) in the nasal passages and the air flow rate while inspiration (determined by readings sensor p1) Contains physical phase difference δ, by the value of which we can judge about the energy dissipation during the air passage through the upper respiratory tract. As shown in the graph (see Figure 2), the time displacement Δt between the maximum pressure drop signal p2 in the nasal passages and pressure drop in the flowmeter is 0.05 s, which corresponds to the phase difference between the signals = 9 °. at this definition of statistical significance, for the parameter in the diagnosis of diseases of the upper respiratory tract that requires further study and medical substantiation.

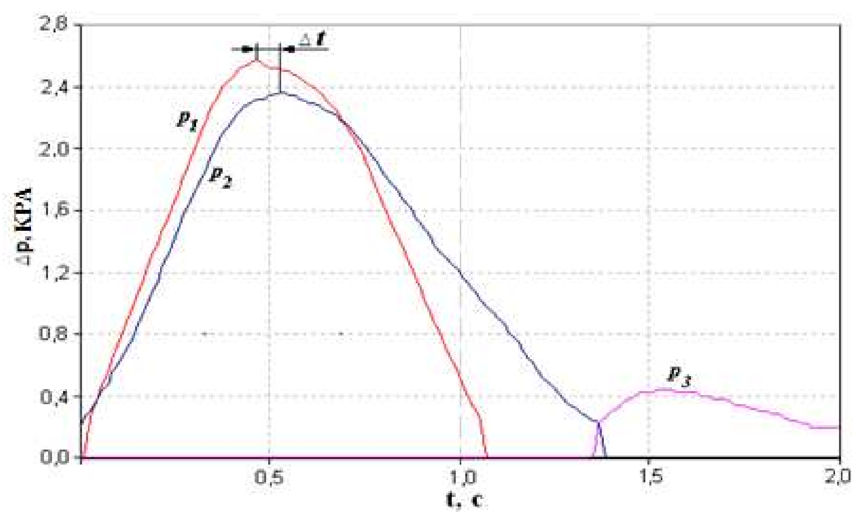

Figure 2: Diagram of the Respiratory Cycle, Indicating the Time Displacement Δt between the Amplitudes of the Pressure Signals for Sensor P1 and P2, That Fixing the Air Flow Rate and Pressure Drop across the Nasal Cavity, Respectively, According to the Dynamic Data (AAR)

As well (see Fig.3) the reading of the sensor p2, which measures the pressure in the nasopharynx (distal tip measuring tube, that located in the mouth cavity), with a breath-hold may differ from zero at hermetically sealed compartment oral cavity from nasopharynx structures of soft palate, and that is about 100 Pa. This index may have diagnostic significance when studying the degree of displacement the soft palate, for example, in treatment of snoring and syndrome obstructive sleep apnea.

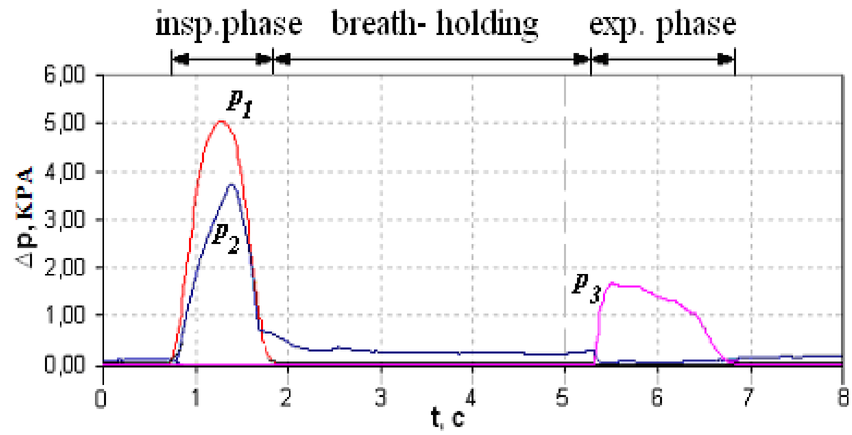

Figure 3: Diagram of the Respiratory Cycle According to Dynamic Data (AIRM) by Hermetically Sealed Compartment Oral Cavity from Nasopharynx Structures of Soft Palate in Phase of Sleep Apnea

CONCLUSIONS

Proposed comparison of discriminant characteristics of rhinomanometry diagnostic methods using the Mahalanobis distance were used to measure the distance between the random vectors of values and generalize the concept of Euclidean distance.

From the results in Table 1, it is clear that the proposed method in our work of rhinomanometry measurement at forced respiration has great (1.4 factor) discriminant features in comparison with traditional methods and reduces the possibility of errors when making decisions of diagnostic solutions from 0.17 to 0.06. This allows the use of this method for functional diagnostics of the upper respiratory tract.

A phase difference is found between a periodically varying external pressure and the air speed inside of the modeled nasal passage. This is defined as the relationship between dissipation of the air flow energy and respiration frequency dependent of the coordinates. It can be seen that at a low frequency of respiration, the maximal dissipation area of respiration power appears on the axis of the nasal passage, whereas at a high frequency, it becomes displaced to the wall region.

The perspective of this work is to develop methods and criteria that allow the differential diagnosis for pathologies of the upper respiratory tract according to rhinomanometry data. Our future enhancement is to develop a multifunctional rhinomanometer, that must be capable to perform direct rear active rhinomanometry with the specified metrological characteristics and a capability to implement additional indirect methods of diagnostics of air conduction of upper respiratory tract when direct measurements cannot be done. The outlook for the work involves the hardware implementation of the complete device, its metrological attestation, development of patient examination technique to ensure repeatability of results and clear criteria for differential diagnostics of various diseases of upper respiratory airway.

REFERENCES

1. Kayser R. Die exacte Messung der Luftdurchgängigkeit der Nase. Arch Otolaryngol 1895; 3: 101-120.
2. Dishoek van HAE, Dishoek van EA. Nasal resistance measuring without breathing. Rhinology 1970; 8: 37-43.
3. Pleger E, Mahn HR, Müller E, Vogt K. Zur oszillatorischen Bestimmung des Nasenwiderstandes. Z Klin Med 1985; 40: 1957-1960.

4. Berdel D, Koch U. Messung der Nasenwegswiderstände (Rhinomanometrie) mit der Oszillationsmethode. Laryng Rhinol 1980; 59: 575-580.
5. Semarak A. Objektive Beurteilung der Nasendurchgängigkeit. Z Laryngol Rhinol 1958; 37: 248-261.
6. Brünings, N.: Verh. Dtsch.Laryngol. 1912 (19), cit. by Semarak (9).
7. Zwaardemaker H. Die Physiologie der Nase und ihrer Nebenhöhlen. In: Denker, Kahler (Hrsg) Handbuch der Hals-Nasen-Ohren-Heilkunde. Bd I, S 439-484, Springer-Bergmann, Berlin München 1925.
8. Y.V Mitin, L.R Krynychko, "Modern etiology, pathogenesis and sinusitis treatment", Mistetstvo likuvannya, n: 3, pp: 52-55, 2004.
9. O.G Avrunin, A.I Bykh, V.V Semenets, "Substantiation basic medical-technology requirements for design multifunctional rhinomanometers", Meeting, scientific works 3rd International Scientific Conference«Functional component base of micro-opto-and nano-electronics. ».kharkiv, Kharkiv National University of Radio Electronics, pp: 280-281, 2010.
10. Technical diagnostics and control of technical condition. Terms and definitions: Government standards of Ukraine2389-94, [implementation date1995-01-01], Kiev: Gosstandart of Ukraine, pp: 24, 1994.
11. A.V Milniki, "Classification of signals in under uncertainty condition", (statistical expert system methods for pattern recognition). Moscow: today, Radio, pp: 329, 1985.
12. Sh. Raudis, "The limited sample in classification tasks", compilation, «Statistical control problems» Vilnius, n: 18, pp: 1-185, 1976.
13. P.F Shapov, "Optimization of information parameters space on based of covariance model dispersion analysis" electro-technology and electro-mechanics, n: 2, pp: 59-62, 2005.
14. V.P Malaychuk, O.V Mozgovoy, O.M Petrenko, "Information-measuring technology nondestructive control", Dnipropetrovsk National University PBB, pp: 240, 2001.
15. T.G Osina, "Using parametric functional differentiate in tasks of measuring control quality", Vestnik, Science and Technology institutions" Kharkov Polytechnic University", n: 9, pp:103-107, 2006.
16. O.G Avrunin, "Methods of calculating the diameter venture nozzle for device by determination fall casting-consumables characteristics nasal passages", Industrial hydraulics and pneumatics, n: 2 (28), pp: 62-66, 2010.
17. N. Johnson, F. Lyon, "Statistics and experiment planning in technology and science", Methods of experimental design, Translated from the English under supervision of E.K. Letsko, Moscow: World, pp: 520, 1981.
18. Richard O. Duda, Peter E. Hart , " Pattern Classification and Scene Analysis ", translated from English, V.L Stefaniuk, Moscow: Science, pp: 512, 1976.
19. H.F. Ismail Saied, A.K. Al_Omari, and O.G. Avrunin, "An Attempt of the Determination of Aerodynamic Characteristics of Nasal Airways," Image Processing & Communications, challenges3, AISC 102. pp 303-310 Springer-Verlag Berlin heidelberg (2011).

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