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Research paper

Use of Fuzzy Logic Methods for Statement of Diseases on the Basis of Symptomatic Model

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Abstract

Finding the answer to the problem of recognizing (diagnosis) patient's state as a whole and its main systems is based on analysis and interpretation of the available data on current state of the patient and his medical history. An important stage of this process is development of a method of forming images of the patient's condition, and models of nosological forms of the disease, which will solve the main task of automating the procedure of recognizing the patient's condition using a multi-dimensional virtual image.

Keywords: *Fuzzy, Symptomatic Model, nosological, multi-dimensional virtual image.*

1. Introduction

The method of forming a multidimensional image of patient's condition is based on the use of two classes of patient's condition: being healthy and not healthy. The patient's condition of being"not healthy" is divided into subclasses in accordance with certain deviations of the current values of clinical data from the norm, describing the characteristic clinical and morphological picture of the corresponding disease.

Assume that a patient's condition is estimated by some finite set of N non-invasive and invasively measured digitized instantaneous values of various clinical data in physical terms that can be thought of as the N-dimensional space of the patient's condition. In this N-dimensional space, virtual volumetric models of various nosological forms of diseases are built Bi as M geometrical places of points, where M is the number of diseases; i = 1; 2; 3 ... n. The coordinates of points in each of the M geometric locations can be represented as a set of specific instantaneous values of various clinical data describing the characteristic clinical and morphological picture of the corresponding disease. To analyze the state, each point of every multidimensional area of the disease is biotrained on the plane coinciding with the plane of the display of a multicolor monitor screen, resulting in the formation of two-dimensional models of various nosological forms of diseases - B2i, which are then visualized, the process of forming two-dimensional models of various nosological forms of diseases.

2. Research metod

Formation of L-map, for this purpose, the direction of the vector in the plane $\{X';Y'\}$, coinciding with the plane of the displaying multicolor screen of the video monitor formed as a result of mapping a point from the N - dimensional space of the disease state onto the plane containing the origin of the given N - dimensional space.

The following basis is defined in the N-dimensional coordinate system:

$$(\vec{p}_0, \vec{p}_1, \dots, \vec{p}_{n-1}) \quad (1)$$

Where $\vec{P}$ is unit two-dimensional vector, $l = \overline{1,n}$. The unit vector is one whose modulus is equal to one:

$$\left|\vec{P}_i\right| = 1 \quad (2)$$

Product of vector $\vec{P}_i$ by number Z_i called vector

$$\vec{l}_l = z_i * \vec{p}_i, \quad (3)$$

Where Z_i– coordinates of some point Z$(Z_1, Z_1, \dots Z_n)$,located in N-dimensional space.

The sum of the vectors is determined by the formula:

$$\overrightarrow{r_q} = \overrightarrow{l_\iota} + \overrightarrow{l_J} \quad (4)$$

Where $q = \overline{1,k}, i = j = \overline{1,n}\ k < n$

To add several vectors, you need to place the beginning of the next vector at the end of the previous one, then the total vector will be directed from the beginning of the first to the end of the last.

$$\vec{R} = \overrightarrow{l_1} + \overrightarrow{l_2} + \dots + \overrightarrow{l_n} \quad (5)$$

Thus, the result of the projection of the point Z with coordinates $(Z_1, Z_1, \dots Z_n)$,located in the N-dimensional space on the plane $\{X';Y'\}$, coinciding with the plane of the displaying multicolor screen of the video monitor, are determined in accordance with the ratio of the form:

$$\vec{R} = \sum_{i=1}^{n} \vec{l}_l \quad (6)$$

The coordinates of the point Z on the plane $\{X';Y'\}$ are determined by the formula:

$$Z_L(x';y') = \sum_{i=1}^{n} z_i * \overrightarrow{p_\iota}, \tag{7}$$

Where $Z_L(x';y')$ – projection coordinates Z $(Z_1, Z_1, \dots Z_n)$points on a plane $\{X';Y'\}$; $(x';y')$- coordinates on the plane $\{X';Y'\}$.

Point coordinates $Z_L(x';y')$ on surface $\{X';Y'\}$. can be found using the matrix form:

$$Z_L(x';y') = \begin{bmatrix} 0 & sin\frac{\pi}{n} & \dots & sin\frac{(n-1)\pi}{n} \\ -1 & -cos\frac{\pi}{n} & \dots & -cos\frac{(n-1)\pi}{n} \end{bmatrix} \begin{bmatrix} Z_1 \\ Z_2 \\ \vdots \\ Z_n \end{bmatrix} \tag{8}$$

where are the coordinates of each vector $\overrightarrow{r_q}$ are determined using the projection of this vector on the X and Y axes, respectively.

Projection vector $\vec{l_i}$ on the X axis is defined as

$$x_{i=} |l_i| * \cos a \tag{9}$$

Projection x_i of vector $\vec{l_i}$ on the Y axis is defined as

$$x_{i=} |l_i| * \sin a \tag{10}$$

Connecting the origin to a point $Z_L(x^i, y^i)$ vector direction is formed

$\vec{Z_l}$.

Stage 2 - the formation of the S-display, which consists in determining the length of the vector $\vec{Z_l}$.

S - mapping a point z with coordinates $(Z_1;Z_2;Z_3 \dots Z_n)$ there is a point Z_s, which is the end of a vector constructed from the origin of two-dimensional space to a point $Z_s(X_s, Y_s)$, the length of which is the Euclidean distance from the point Z to the origin of coordinates in the N-dimensional space of the patient's state, and the collinear vector constructed from the origin of the coordinates of the two-dimensional space to the point Z_l, calculated in accordance with the relation (2.8).

This Euclidean distance to a point is determined from the relation

$$|Z_S| = \sqrt{(z_1 - c_1)^2 + (z_2 - c_2)^2 + \dots + (z_n - c_n)^2} \tag{11}$$

Where $(C_1, C_2, \dots, C_n)$ is the origin of coordinates in the N-dimensional space to determine the patient's disease state.

As a result of the first and second stages of the mapping, we find the vector $\vec{Z_s}$, which means the true coordinates of the corresponding point of the N-dimensional space of the patient's disease states on the plane $\{X';Y'\}$.

We illustrate the procedure for performing the two-step mapping process described above using the example of a 4-dimensional space (N = 4) and a given point in a given space.

For ease of analysis, but without losing generality of reasoning, we place the origin of 4-dimensional space in a point with coordinates (0, 0, 0, 0), we illustrate the process of forming L - displaying a point with coordinates (-1; 4; 2; 1.5) on the screen plane.

Calculate the length of the vector $\vec{Z_s}$ according to the formula:

$$|Z_s| = \sqrt{(-1)^2 + (4)^2 + (2)^2 + (1.5)^2} = 4.8b \tag{12}$$

As a result of displaying each point of each multidimensional region of the Vina disease, the plane coinciding with the plane of the multicolor screen of the video monitor displaying the above method, two-dimensional models of various nosological forms of the patient's diseases are formed - *B2i*, which are then visualized.

Next is one of the known methods of digitization and weight processing recorded in the physical quantities of the instantaneous values of each indicator of the clinical data of a particular patient. Then build a volume image of the patient's disease state - the point *AN (t)* as a set of geometric locations of the points *AN (t)*, where the coordinates of each of its points are determined by the combination of non-invasive and invasively measured in physical terms digitized instantaneous values of various clinical data characterizing the current patient's condition in N-dimensional space. Two-dimensional images of the patient's state are formed - *A2 (t)* in the form of projections of formed points *AN (t)* onto the plane coinciding with the plane of the displaying multicolor screen of the video monitor, where the coordinates of each two-dimensional state image *AN (ti)* are determined according to the method described above [4- 5].

In this way, a two-dimensional image of the A2 (t) symptoms and two-dimensional B2i disease regions are formed, representing the projections AN (t) and Bi to the {X ’; Y’} plane (Fig. 1), coinciding with the plane of the displaying multicolor screen of the video monitor.

3. Results and analysis

We illustrate the procedure for performing the two-step mapping process described above using the example of a space and a given point in a given space [1-3]. In this way, a method for assessing the patient's condition is formed on the basis of relative position topology.

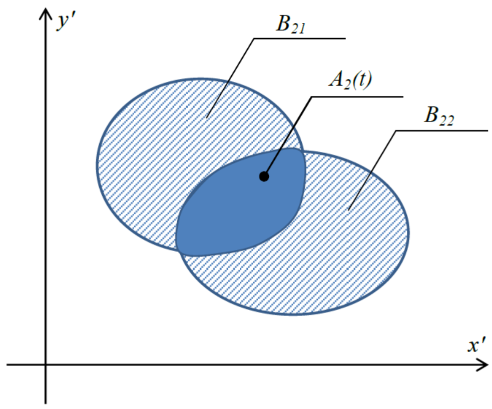

Fig. 1: Topology of the relative position on the plane $\{X';Y'\}$, two-dimensional image of states and two virtual two-dimensional models of nosological forms of diseases.

$$A_i(t)\square\square B_{2i} \tag{13}$$

$$A_i(t_i)\square B_{2i} \tag{14}$$

And decide on the absence of the disease or the presence of the corresponding disease of patient when performing one or another of these conditions $A_2(t)\ (B_{2i})$ и $A_2(t_i)\ (B_{2i})$. That is, depending on which particular two-dimensional model formed on the plane B_{2i} the current two-dimensional state image is located $A_2(t_i)$, The doctor can make a conclusion about possible diseases of the patient at a given time.

4. Conclusion

In this paper a mathematical model of a medical information and diagnostic system is presented, which makes it possible to develop an unambiguous control medical solution, and to increase accuracy of the diagnosis up to 90%. A method is proposed that implements the presented method of forming a multidimensional image of patient’s condition and its visualization, containing the basic theoretical principles of making medical management decisions (including the procedure for eliminating ambiguity of taking a medical management decision) and information processing (as a set of non-invasive and invasively measured in physical quantities of digitized instantaneous values of various clinical data characterizing the current state of the patient).

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