Creation of digital twins of neural network technology of personalization of food products for diabetics

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***Abstract*—The article discusses the problems of creating Digital Twin for use in neural network technology for personalizing food products for people with a genetic predisposition to diabetes. When designing an information system for personalizing food products, it is proved that the main direction of development is the modeling of a Digital Twin of the product and the consumer, as well as the determination of the technologies that form the basis of the personalized food model to create an accurate, correctly functioning system.**

***Keywords**—Digital Twin, neural network, food personalization, diabetes predisposition*

I. Research

In the model of personalized nutrition for diabetics, a large number of different food and technological technologies play the most important role: biological activity; canning technologies; fortification of products; product design and engineering.

In addition, to solve the problem requires information technology: BigData; Protection of personal information; Digital Twins product and consumer.

Important technologies for application and maintenance: platform; Delivery; culinary escort. It is necessary to use medical technology: genomic research; analyzes. Also, in the personalized food model, it is necessary to remember the individual goals and limitations of the consumer, since they will help to increase the accuracy and functionality of the information system for personalizing food products for people with a genetic predisposition to diabetes.

Process visualization was carried out using a process modeling program - Ramus. In order for the model to “form” the recommended (personalized) food, it needs to go through 3 stages:

1. The stage of formation of the consumer's Digital Twin , for its further use in the inference machine. To create a digital consumer double, it is necessary to identify the individual limitations of the consumer himself, as a result of which we obtain the values necessary to fill out the electronic medical record. Next, a survey is conducted on the taste preferences of the consumer and the identification of his individual goals to which he aspires. Then there is a processing of the received data. At the output of such a subprocess, we get a consumer Digital Twin , which is necessary for the inference machine.

2. The stage of formation of a Digital Twin for the product, for its further use in the inference machine. Detailedization of this process is not necessary as the formation of a Digital Twin product occurs by entering values into the system database.

3. The stage of the "logical inference machine". At this stage, there is a preprocessing of the received data from the Digital Twin of the product and the consumer and data on the effect of food and various substances on human health. After processing, the already trained forecasting model is applied to the obtained data, which will be implemented in a digital food personalization system for people with a genetic predisposition to diabetes. Further, the forecast results are processed, forming nutrition recommendations.

Developing the Consumer Digital Twin Model

Before developing a consumer Digital Twin model, the technologies used in this model need to be considered.

When with a medical systems building, it is important to bear in mind that the patient 's electronic medical record is not the only category of these systems. In total, three categories can be distinguished:

- *Electronic Patient Record-centric* - this includes what applies to a particular patient. Applications are not limited to only storing the patient 's demographic data and his or her medical history.

- *Public Health Information Networks* - systems at this level are abstracted from the individual and aggregate quantitative data from multiple patient-oriented systems to predict events such as epidemics and bioterrorism.

- *Clinical Research Support* - this group includes systems for decision making and drug modeling.

There is no explicit boundary between the presented categories, the incoming data flows from one to another, is processed, supplemented and returned. Using the standard Health Level 7 (HL7) as a database structure will help store all received messages from any other system. RIM is based on 4 basic classes: Entity, Role, Participation, and Act, and two additional classes to describe relationships: Role Link and Act Relationship. The use of the term "class" is due to the fact that RIM follows the basic principles of inheritance in the PLO. The standard explicitly states:

- Generalization - when the heir class includes all the properties of the parent class.

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- Specialization - The heir class overrides some of the parent 's functions and also defines additional properties for even greater specialization.

To get the required messages, HL7v3 uses the refinement process, which results in the creation of multiple Domain Message Information models (D-MIM) for domains and multiple Refined Message Information models (R-MIM) in each of them. From R-MIM, following the same rules, the final Hierarchical MessageDescriptions (HMD) are obtained from which, in turn, messages are constructed.

Next, it is necessary to describe one of the HL7 standards developed to standardize the structure and ensure semantic compatibility of medical systems in the exchange of medical information and / or medical documents. This is the Clinical Document Architecture (MDA) standard [4]. The second release of this standard guarantees the presence of seven characteristics of the CDA document, such as:

- security of the submitted information;
- managing the submitted information;
- support for authentication requirements for all submitted information;
- support for the context of the information provided;
- support for integrity of information;
- the ability to read the information provided by a person;
- support for binary information, such as multimedia components, PDF, images, and others.

Thanks to these characteristics, CDA becomes extremely flexible for use in various fields. And even though CDA is considered an extremely complex standard among medical system developers, it has become one of the most successful ones developed by HL7 for integrating medical data. Most medical systems currently encode information in one of nine possible CDA document templates. For example, the Continuity of Care Document (CCD) is one of these templates.

Continuity of Care Document is an XML - based standard aimed at encoding the structure and semantics of a patient's medical record for subsequent exchange.

Integration of the information system for food personalization for individuals with a genetic predisposition to diabetes mellitus with EMC will increase the information content of the Digital Twin and the functionality of the information system "food personalization". Thus, to create a model of a Digital Twin, it is necessary to use not only data about individual goals and restrictions of the consumer, but also data from electronic medical records [3].

Based on the presented model of the consumer's Digital Twin, its structure will consist of three tables: patient; taste preferences; individual goals.

Patient Table

In the Patient table, we will create 4 fields for storing our data.

- ***Id***-the serial number or counter of our patient. We will make the Id data type int, and add the unsigned keyword to exclude negative numbers. Adding the AUTO_INCREMENT attribute for automatic increment in step 1.

- ***HL7***-fields for linking to the structure of tables from the HL7 standard that are included in the patient table. Data type int

- ***Taste Preferences***-a field for storing taste preferences included in the table-patients. Data type ***- int***

- ***IndividualPurposes-field*** for storing individual goals included in the table-patients. Data type - ***int***

Table "Taste preferences"

Next, we need to create a table "Taste preferences" which will store the names of, for example, cocoa products. Let's call it "Test Preferences". In the Taste Preference s table, we will create two fields for storing our data.

- ***Id***-the serial number or counter of our patient. We will make the Id data type int, and add the unsigned keyword to exclude negative numbers. Adding the AUTO_INCREMENT attribute for automatic increment in step 1.

- ***Taste Preference***-field for storing taste preferences in the table. Nvarchar (1500) data type.

Individual goals table

Next, we need to create a table "Individual goals" which will store the names of, for example, cocoa products. Let's call it "IndividualPurposes". In the Individual Purposes table, we will create two fields for storing our data.

- ***Id***-the serial number or counter of our patient. We will make the Id data type int, and add the unsigned keyword to exclude negative numbers. Adding the AUTO_INCREMENT attribute for automatic increment in step 1.

- ***Individual Purpose***-field for storing individual goals in the table. Nvarchar(1500) data type. For example, diet chocolate consists of ingredients belonging to three main groups: sweetener, cocoa products, and additional raw materials. Based on this, the structure of the Digital Twin will consist of four tables: Chocolate; Sweeteners; Cocoa products; Additional raw materials.

Table "Chocolate"

First, we need to create a product table, for example, "Chocolate". Let's call it "Chocolate". In the Chocolate table, we will create 6 fields for storing our data.

- ***Id***-the serial number or counter of our chocolate. We will make the Id data type int, and add the unsigned keyword to exclude negative numbers. Adding the AUTO_INCREMENT attribute for automatic increment in step 1.

- ***Cocoa Products***-field for cocoa products that are part of chocolate. Data type int;

- ***Sugar Substitutes***-field for sweeteners that are part of chocolate. Data type int;

- ***DopMaterials***-field for additional raw materials that are part of chocolate. Data type int;

- ***Calories***-a field for storing data about the caloric content of a chocolate product. Nvarchar(50) data type);

- ***DailyNeeds***-a field for storing data about the daily needs of vitamins and chemicals. elements of a chocolate product. Nvarchar (50) data type;

Table "Sweeteners"

Next, in the same way, create a table "Sweeteners" which will store the names of sweeteners. Let's call it "Sugar Substitutes".

Table "Cocoa products"

Next, in the same way, create a table "Cocoa products" in which the names of cocoa products will be stored. Let's call it "Cocoa Products".

Table "Additional raw materials"

Next, we need to create a table "Additional raw materials" in which the names of additional raw materials will be stored. Let's call it "DopMaterials".

II. RESULTS OF THE STUDY

With power .NE T Fr amework-t ekhnologiya re alizovan PR ototype of the system of personalization of food products for individuals who have a genetic predisposition to diabetes mellitus, VK luchayuschiy in se BYA mo del ognozirovaniya on the basis of neural networks. This system has the functionality of not only food personalization systems, but also medical ones.

Based on the research, a model of personalized nutrition was built [5], the models of Digital Twin and Digital Twin were developed, and they are presented in the system as a structured data set. Using the Microsoft SQL Server Management Studio environment, the database structure of the digital food personalization system for individuals with a genetic predisposition to diabetes was described and created. This structure will allow you to correctly display the data that is in the system, and the created views will provide free access to the necessary up-to-date information.

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REFERENCES

[1] Dassault Systems [Electronic resource]. – Mode of access: https://blogs.3ds.com/russia/Digital-Twin/ free.

[2] Big data / School of big data [Electronic resource]. – Mode of access: https://www.bigdataschool.ru/bigdata/Digital-Twin-Plm-Iot-Big-Data.html free.

[3] EverCare / Digital medicine [Electronic resource]. – Mode of access: https://evercare.ru/tsifrovoi-dvoinik-cheloveka free.

[4] Clinical Document Architecture (CDA) / Habr [Electronic resource]. - Access mode: https://habr.com/ru/post/255879/, free.

[5] Vaskovsky A.M., Chvanova M. S. Designing a neural network for food personalization in individuals with a genetic predisposition to diabetes // 3rd school on the dynamics of complex networks and their application in intelligent robotics (DCNAIR), Innopolis, Russia, 2019, P. 175-177.