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SYSTEM FOR DETECTING AND ANALYZING TEXTUAL INFORMATION OF PRODUCT COMPOSITION

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Abstract*—The paper substantiates the need to obtain an assessment of the harm of food products for consumers with chronic diseases or allergies, which is important to prevent a possible worsening of the course of the disease or eliminate an acute allergic reaction of the human body to hazardous ingredients present in the product. It is proposed to use food labels and packaging as the primary sources of information about the food product that is available to the consumer. It is shown that, the printed information on the packages of Ukrainian food products meets the requirements of the law "On Consumer Information on Food Products" and the labeling on food labels is presented in the text-graphic form. In this work it is used convolution neural networks for text-graphic information processing. It is proposed and substantiated the system structure for detecting and analyzing the text-graphical information of product composition. It is developed mobile software solution.*

Index terms—Analyzing product composition; assessment of the harmfulness of food; decision-making algorithm; intellectual system; text detection.

I. INTRODUCTION

To take care of your health and prevent health problems, it is necessary to pay special attention to food products, before buying them, and especially to the composition of these products. According to the Ministry of Health, 2/3 of all diseases in Ukraine are caused by harmful food products. One of the most common causes of food poisoning and digestive system problems is the presence of toxic chemical ingredients in foods that have nothing to do with nutritional value [17].

Food products have a complex structure and a large number of ingredients of different chemical composition. The quality of the whole food product depends on the properties of the ingredients of the food composition. In general, food ingredients are divided into two groups, those that are useful for human life and health and those that perform technological functions. Nutrients provide the energy value of products (macronutrients) or can bring additional benefits from the food product, for example, improve the physiological functions of the body (micronutrients). Substances that are added to food to maintain or improve the safety, freshness, taste, texture, or appearance of food are known as food additives. Most of the harmful to health ingredients are synthetic non-nutrients obtained through chemical synthesis – food additives [9].

Following the Law of Ukraine "On approval of Sanitary rules and regulations for the use of food additives" food additives are natural or synthesized substances that are specially introduced into food products to provide them with necessary properties (for example, organoleptic, technological). Food additives can remain in food products as is or in the form of substances that are formed after the chemical interaction of additives with food components [22].

The modern development of the food and chemical industry makes it possible to introduce food additives into food not only for technological needs, such as extending the shelf life but also to improve the taste and color of the product, improve the appearance to make the product cheaper. Due to this development of food technology, the number of food additives has increased to 2800 units [25].

II. THE PROBLEM OF DETERMINING THE COMPOSITION OF FOOD PRODUCTS ACCORDING TO THE PRINTED INFORMATION OF THE MANUFACTURER

Preserving agents, stabilizers, and emulsifiers, flavoring agents are used daily and accumulate in the human body over a long period of life. The World Health Organization notes that, for example, flavoring agents in the wrong amount cause

hypersensitivity to certain foods or idiosyncratic reactions (iodine allergy) [18]. Sweeteners such as cyclamates (E952), aspartame (E951), saccharin (E954), which are found in many foods such as cookies and biscuits, sauces, ketchup and mayonnaise, carbonated beverages, sour milk desserts, yogurts, kefir, have the permissible amount of consuming per day and are not recommended for consuming over a long period. [17]. Also, the well-known palm oil, which is still used in food (margarine, some cheeses, cakes with buttercreams, chocolate, chocolate sweets, etc.) due to a large amount of saturated fatty acids, causes cardiovascular disease and is used to make production cheaper [12], [27]. The harm of saturated fats contained in palm oil, as well as in meat and dairy products is stated in a report submitted by the World Health Organization [5]. Soy lecithin (E471), which is a common emulsifier and stabilizer and is used even in bread, is contraindicated for people who have problems with the liver [7]. Sugar, which is now added to almost all foods, such as pastries, bread, sauces, and ketchup, to improve the taste, but in excess amounts leads to diabetes [11].

In many countries, among all existing food additives, the use of only 50-60% is allowed. In Ukraine, it is prohibited to use only additives that belong to the category of very dangerous. The use of all other additives is permitted. The main requirement for the food manufacturer is to indicate the name and index of the food additive [21]. By paying attention to the product composition, one can find that a product that is labeled "organic" or "natural" contains synthetic additives; hard cheese contains dye-ware colors and potassium chloride (which causes irritable bowel syndrome and ulceration), and so on. Unfortunately, it's not just food additives that cause health problems - a large number of people suffer from food allergies. According to the Information note about Food Allergy of the World Health Organization, more than 70 foods can cause food allergies. The only way to prevent allergies is to avoid allergens, including cereals that contain gluten, dairy, cocoa, peanuts, and other types of nuts, eggs, and fish, mustard, celery, etc. [16]. Allergen products cause skin diseases, gastrointestinal disorders, breathing problems, or even affect the central nervous system. Allergen products are being used to make food products in which they do not need to be at all. For example, dark chocolate may contain egg products and wheat gluten.

Another problem for many people is lactose intolerance. The body cannot break down milk sugar-lactose, which is in all, without exception, dairy products, bread, flour, ham, and sausages, sweets, chocolate, and cocoa, dressings for salads, and ketchup, etc. According to the Ministry of Health, more than 75% of the population suffers from this intolerance. [28], [14]. Intolerance causes not only discomfort after eating dairy products but also destroys the intestinal villus, which impairs its function. The only way out for people with lactose intolerance is to completely abandon foods that contain dairy products, including desiccated milk.

Consequently, consumers must understand what include food products they buy and consume. Therefore, consumers must understand where to look for the necessary information about the food product, what information food manufacturers should provide.

III. State Standards for Food Labeling

Food labels and packaging are the primary sources of information about the food product that is important to the consumer. According to the Law of Ukraine "On Consumer Information on Food Products", labels are words, descriptions, signs for goods and services, graphics or symbols relating to food, one place on any package [24]. That is, labeling is any textual and graphic information presented on the manufacturer's label. The main requirements for labeling are adequacy and reliability, and therefore following the third section of the Law of Ukraine «On information for consumers about food products», manufacturers are required to provide such textual information about the product as name, presented in a form understandable to consumers; list of ingredients (product composition); information on the physical state of the product, for example, frozen or sublimated; conditions of storage or use; country or place of origin; any ingredients or processing aids that are used in the production or preparation of the food product and remain present in the finished product, even in a modified form (food additives); nutritional information; expiration date [24]. These food labeling standards are presented in the Codex Alimentarius, which is a generally accepted standard for labeling packaged food, implemented in many countries, including Ukraine. Food manufacturers are obliged to provide adequate information on the list of ingredients, the presence of food additives, and other information on product packaging, and not to overlap in any case with textual or graphical information [4]. Thanks to adequate food information, consumers can make a conscious choice. Graphical information gives an understanding of the quality of food products or the environmental friendliness of packaging or

organicity. For example, if the content of genetically modified organisms in products exceeds 0.9%, the label "GMO" is a mandatory requirement. Otherwise, a "GMO-free" label is applied.

According to the standards mentioned above, labeling on food labels is presented in the text-graphic form. By reference to the figures below, the printed information on the packages of Ukrainian food products meets the requirements of the law.

The form of presentation of information on food packaging is a system of blocks, which includes an information block with composition, an information block with nutritional value, an information block of product weight, an information block of storage conditions, an information block with a barcode, etc. In some images, the text of the composition is quite small, which makes it difficult to read. The most important information that allows the consumer to analyze the product is the informational block of food composition - the ingredients list after the word "Composition" or "Ingredients" located at the top of the label.

Fig. 1. Label of hard cheese ‘Holland’

Consider the composition of hard cheese, which has a medium price, and immediately notice such ingredients as hardening agent calcium chloride (causes intestinal diseases and ulcers) , dyestuffs annatto extract (causes food allergies [1]), potassium nitrate, which is also used in the production of glass and rocket fuel (moderate toxicity, causes headaches and dizziness, nephritis and breathing problems for people with asthma [6]), chymosin (may cause allergic reactions, not recommended for pregnant women). From all the above, it is clear that this cheese is very harmful to health.

Another example is the usual milk chocolate, which children enjoy eating. We immediately notice a large number of dairy products and sugar, so this product is no longer recommended for people with lactose intolerance and diabetes. Under the names, non-hydrogenated and palm kernels are palm oil (which causes cardiovascular disease), synthetic soy lecithin E476 (used to make production cheaper, although tested and approved by the Food Standart Agency [2]), ammonium bicarbonate (approved, but ammonia may be released during the decomposition of carbon monoxide [2]). The composition is quite controversial, and although certain additives have passed some tests, this product will not be recommended as not harmful due to the presence of palm oil and belongs to the category of medium harmfulness.

According to all mentioned above, the World Health Organization recommends consumers be familiar with the composition of products. But consumers do not want to spend time studying the characteristics of each component that is part of it - it is important for consumers quickly to choose a product in the store.

IV. The Need to Create a System for Detecting and Analyzing Textual Information of Product Composition

Even though the food packaging contains all the essential information about the food product, the results of surveys conducted among Europeans showed that 52.2% of consumers do not read and don't pay attention to the composition of the food packaging. Among consumers who check the composition of food products, 57.7% of consumers around the world do not understand the product composition, are not familiar with the ingredients in the product composition and do not know what they are used for, while 39.7% understand only partially [10].

Difficulty with understanding and unwillingness to read the composition of products are caused by newly introduced terms or food additives that are unfamiliar and incomprehensible to humans. The manual analysis of the composition, shown in the previous section, requires much time and is generally undesirable. But to understand the product composition, it is necessary to thoroughly examine each component to give an objective assessment of the harm. Usually, the average consumer does not have time for all this.

According to the fact that most of the population does not read the composition of products at all, and people who read it does not understand it at all, there is a need to create a system that quickly and easily will provide consumers with all information about ingredients in the food composition, its characteristics, and give an assessment of the harmfulness of the product by food packaging. This system is of great social importance and aims to help

consumers make informed choices and prevent health problems.

The purpose of the article is to analyze the structure of the created system to identify and analyze the composition of products, justify the need to create this system. **It follows from the above that there is the need to create a system that should:**

- be fast, convenient, and accessible to consumers;
- process the list of ingredients from the food composition block and give the user all its characteristics;
- save the consumer's time spent on the introduction of ingredients manually;
- be able to search for ingredients to obtain its characteristics and properties;
- allow the user to enter their preferences and restrictions (or allergens) in ingredients of the food composition;
- have a component for the analysis of the harmfulness of each ingredient, which based on the food composition and taking into account all the limitations of the user, will be able to assess the food product;
- have a large database of products;
- be able to work without a network connection;
- have a component for presenting a hazard assessment and listing all ingredients along with their characteristics.

The need to create a mobile application as a quick and convenient way for consumers to obtain an assessment of the harmfulness of the food composition follows from all requirements to the system above. The subject environment in the developed application are images that contain the text of the food composition.

Firstly, similar existing systems were analyzed. Today, among the mobile systems that should perform similar to the system is being developed are the following: Naturometr, Open Food Facts, Food Scanner. The principle of operation of the 'Naturometr' and 'The Open Food Facts' applications is based on scanning the bar code with the phone's camera, and as a result, a product evaluation should be provided. But applications have the following disadvantages system does not recognize the food products of the Ukrainian market; their database is small, so you have to add food products by yourself if they are absent.

The two applications analyzed above should provide an assessment of the harmfulness of food, but because of the impossibility of recognition, it can be concluded that systems that scan the barcode of products are ineffective due to the constantly limited database and the need to add new products, and therefore was found the application, which scans the text of the composition of products - Food Scanner. The only thing that can be determined is that the application has a manual search with links to Wikipedia articles that is not understandable information for consumers. After a brief review of the most popular applications, we can conclude that today there is no convenient intelligent system that could recognize the food composition on the Ukrainian market, give product characteristics and assess the harmfulness of the product.

Consequently:

- the mobile application will use the phone's camera and make clear images with the text of the food composition (for example, the figure above) to reduce the time spent on manually searching for ingredients and their properties;
- it follows from the previous paragraph that the system should have a software module for image processing, extraction and conversion of textual information of the image into text, and therefore the system should have a module for intelligent text detection and recognition;
- the application contains a component 'personal account', in which the user will add their restrictions and allergen ingredients;
- the application should contain a software module that analyzes the ingredients obtained after recognition, and according to their characteristics to assess the harmfulness of the whole food product;
- it follows from the previous paragraph that:

a) there is the need to have an extensive product database that will be store all the presented ingredients with their characteristics;

b) there is the need to create and use a decision-making algorithm that will analyze the textual information of the food composition and, based on the characteristics of each ingredient, give an overall assessment of the food, it means an assessment of the harmfulness of the food product to a particular consumer;

- the application has a monolithic architecture to provide work in the absence of a network and solve the problem of scalability;
- the application contains a component for viewing historical data and quick access to products previously scanned by the user;
- the application has a component for presenting the results.

V. THE STRUCTURE OF THE SYSTEM

According to all mentioned above the system has the following structure (Fig. 2). The system is divided into five levels, which interact closely with each other. The first level – presentation level is a user interface; the business logic level is the implementation of the subject area; the infrastructure level is software for intelligent text recognition of the composition; platform level represents the interaction of platform components, such as notification, camera, geolocation with system components; data level is a database and interaction with it.

The presentation level includes three components: the 'personal account' component, the component for displaying scan results, and the historical data view component. The personal account component allows the user to enter personal data such as restrictions, allergies, health problems, preferences, which will be taken into account when assessing the harmfulness of a food product. So, if there is an ingredient that is part of the user's restrictions, it will have the highest level of harm, and the system will inform the user about the presence of this ingredient in the food product. The component for displaying scan results is a presentation component that displays a product hazard assessment and a list of products with their characteristics. The historical data viewer component stores and presents information about previously scanned foods for quick access and resource savings for image and composition reprocessing. The 'personal account' component interacts with the database integration component to store information entered by the user. The component for displaying the results of scanning interacts with the component for analyzing the composition of products and displays the result of assessing the harmfulness of the product.

The business logic level includes a component of product composition analysis and represents the algorithmic support of the system – the decision-making algorithm. Based on the text, recognized from the image, the algorithm analyzes the ingredients and calculates the assessment of the harmfulness of the food product.

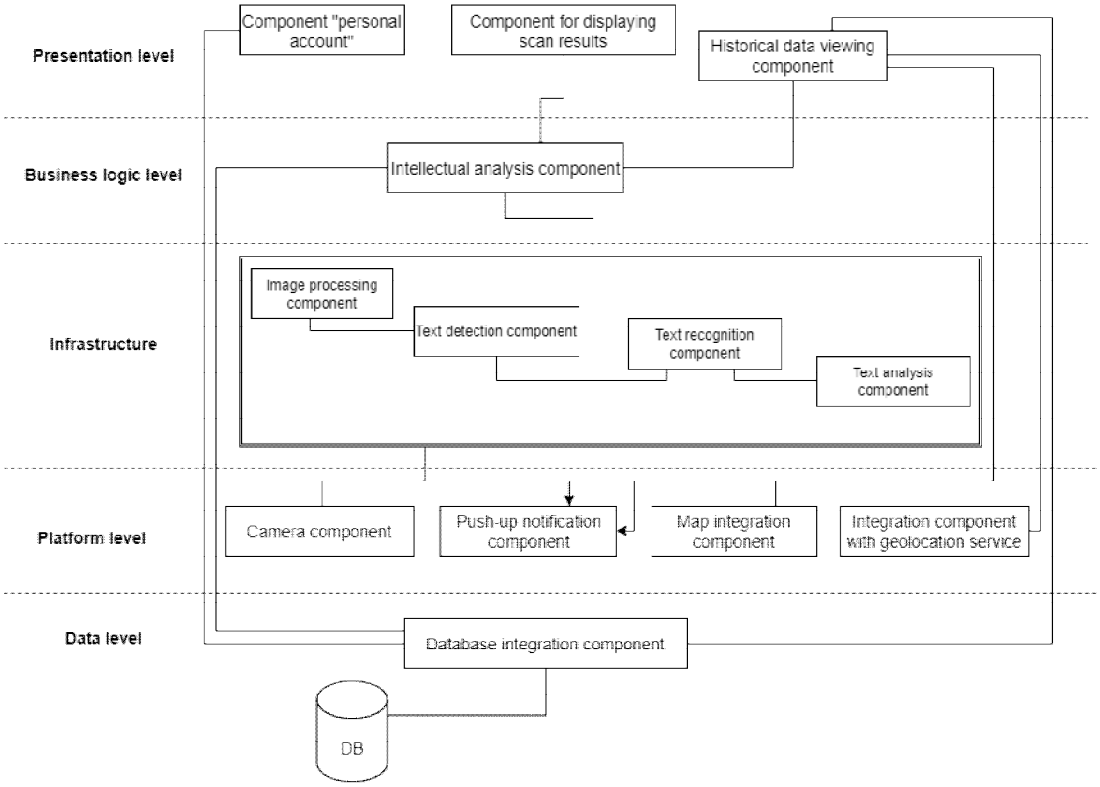

Fig. 2. The structure of the system

The infrastructure layer is software for processing and recognizing text in images with the composition of products. Therefore, the image processing component performs pre-processing: contrast adjustment, image binarization to increase the speed of further recognition. The text detection component finds the letters in the image and extracts the text of the product composition in the form of an array of images. The text recognition component receives a set of single-letter images from the previously described component and recognizes letters using a neural network classifier.

The text analysis component deals with the division of the text into lines, composing letters into words. If it is necessary, the word is filled with missing letters based on the dictionary of the database.

The platform level includes the interaction of levels with platform mechanisms for ease of use of the application. The image capture component interacts with the camera and uses the camera to capture images. The push notifications component is responsible for sending reminder notifications to the user. The map integration component is used for graphical map display. The map interacts with the historical data view component and is needed to store locations of stores where food product has been scanned. The geolocation integration component makes it easy to determine the user's current location to store relevant data in the historical data view component. The data level includes a database integration component and gives other components access to data access mechanisms.

This structure of interconnected components helps abandon the client-server architecture, gain constant access to the use of the application, and obtain an assessment of the composition of the food product.

VI. CONCLUSIONS

Due to the presence of a large number of harmful ingredients in food products today and because of the absence of process automation many consumers ignore the product composition and eat harmful foods, it can be concluded that there is a high need for a system of intelligent, personalized analysis of product composition.

In contrast to existing solutions that provide feedback on the product only in the presence of an identifier obtained by scanning the barcode in the database, the presented system recognizes the text of the food composition and, therefore, covers a much wider range of food products. There is no need for a server, so excellent scalability and accessibility can be achieved. During the implementation of the application, an independent reusable component, which can be supplied as a separate library for quick text recognition, and the component for analysis of product composition for the assessment of product harmfulness were developed.

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В. М. Синеглазов, О. С. Козак. Система виявлення та аналізу текстової інформації про склад продукту
У роботі обгрунтовано необхідність отримання оцінки шкоди харчових продуктів для споживачів з хронічними захворюваннями або алергією, що важливо для запобігання можливому погіршенню перебігу захворювання або усунення гострої алергічної реакції організму людини на шкідливі інгредієнти, присутні в продукті. Пропонується використовувати етикетки та упаковку харчових продуктів як первинні джерела інформації про харчовий продукт, яка є доступною для споживача. Показано, що друкована інформація на упаковках

українських харчових продуктів відповідає вимогам закону «Про інформацію для споживачів щодо харчових продуктів», а маркування на етикетках харчових продуктів представлено у текстово-графічному вигляді. У даній роботі використані згорткові нейронні мережі для текстово-графічної обробки інформації. Запропоновано та обґрунтовано структуру системи виявлення та аналізу текстово-графічної інформації складу продукції. Це розроблене мобільне програмне рішення.
Ключові слова: Аналіз складу продукту; оцінка шкідливості їжі; алгоритм прийняття рішень; інтелектуальна система; розпізнавання тексту.

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В. М. Синеглазов, О. С. Козак. Система обнаружения и анализа текстовой информации о составе продукта

В работе обоснована необходимость получения оценки вреда пищевых продуктов для потребителей с хроническими заболеваниями или аллергией, что важно для предотвращения возможного ухудшения заболевания или устранения острой аллергической реакции организма человека на вредные ингредиенты, присутствующие в продукте. Предлагается использовать этикетки и упаковку пищевых продуктов как первичные источники информации о пищевом продукте, доступной для потребителя. Показано, что печатная информация на упаковках украинских пищевых продуктов отвечает требованиям закона «Об информации для потребителей по пищевым продуктам», а маркировка на этикетках пищевых продуктов представлена в текстово-графическом виде. В данной работе использованы сверточные нейронные сети для текстово-графической обработки информации. Предложена и обоснована структура системы выявления и анализа текстово-графической информации состава продукции. Это разработанное мобильное программное решение.
Ключевые слова: Анализ состава продуктов; оценка вредности продуктов питания; алгоритм принятия решений; интеллектуальная система; обнаружение текста.

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