AI-powered Nutrition Analyzer for Fitness Enthusiast

Abstract:

Artificial intelligence (AI) as a branch of computer science, the purpose of which is thought processes, learning abilities and knowledge management, finds more and more Applications in experimental and clinical medicine. In recent decades, there has been an expansion of AI applications in biomedical sciences. The possibilities of artificial intelligence in the field of medical Diagnostics, risk prediction and support of therapeutic techniques are growing rapidly. The aim of The article is to analyze the current use of AI in nutrients science research. The literature review was Conducted in PubMed. A total of 399 records published between 1987 and 2020 were obtained, of Which, after analyzing the titles and abstracts, 261 were rejected. In the next stages, the remaining Records were analyzed using the full-text versions and, finally, 55 papers were selected. These papers Were divided into three areas: AI in biomedical nutrients research (20 studies), AI in clinical nutrients Research (22 studies) and AI in nutritional epidemiology (13 studies). It was found that the artificial Neural network (ANN) methodology was dominant in the group of research on food composition Study and production of nutrients. However, machine learning (ML) algorithms were widely used In studies on the influence of nutrients on the functioning of the human body in health and disease And in studies on the gut microbiota. Deep learning (DL) algorithms prevailed in a group of research Works on clinical nutrients intake. The development of dietary systems using AI technology may Lead to the creation of a global network that will be able to both actively support and monitor the Personalized supply of nutrients.

Lack of proper diet causes many diseases like night blindness, gum death, rickets, osteomalacia, etc. Similarly, undernutrition will cause a low intelligence quotient (IQ), osteoporosis, anemia, scurvy, pel-Lagra, etc. Over-nutrition will result in obesity, Type II diabetes mellitus, and ischemic heart diseases. Also, the unhygienic intake of food, intake of food on no fixed time, intake of fast food intake of other Unhealthy stuff can lead to irregularities in the human body. Adopting healthy habits, physical activity, Exercise, sports, and walking can lead to a healthy lifestyle of an individual. In addition, today's busy Schedule and less time availability restricts individuals to visit the doctors or nutritionists. Many mobile Applications were developed for monitoring and calculating an energy level as well as healthy nutrition. This review chapter has assessed the use and features of various mobile phone health applications, which Helps individuals to overcome and monitor the above-mentioned health-related issues.

Introduction:

The term "artificial intelligence" was first proposed in 1955 by the American computer Scientist John McCarthy (1927–2011) in the proposal of a research project, which was carried Out the following year at Dartmouth College in Hanover, New Hampshire [1,2]. Artificial intelligence (AI) as a branch of computer science, the purpose of which is to Imitate thought processes, learning abilities and knowledge management, finds more and More applications in experimental and clinical medicine. In recent decades, there has been An expansion of AI applications in medicine and biomedical sciences. The possibilities Of artificial intelligence in the field of medical diagnostics, risk prediction and support of Therapeutic techniques are growing rapidly. Thanks to the use of AI in ophthalmological [3],Radiological [4] and cardiac [5] diagnostics, measurable clinical benefits have been obtained. AI was used in research on new pharmaceuticals [6]. The development of AI also provides New opportunities for research on nutrients and medical sensing technology.

Nutrition is considered one of the foundations of athletic performance, and post-Workout nutritional recommendations are fundamental to the effectiveness of recovery and Adaptive processes. Therefore, an effective recovery strategy between workouts or during Competition can maximize adaptive responses to various mechanisms of fatigue, improving Muscle function and increasing exercise tolerance. An effective intervention to restore the Physical fitness of an athlete by monitoring the regimen and diet, timely admission, and the Specified quality and quantity of food components is considered fundamental [1].Currently, new directions in dietetics are being formed, focusing on the creation of Personalized diets.

These include (1) genetic studies that are likely to determine people's Predisposition to a particular type of food and the degree of risk of food-related diseases studies on the diversity of the human microbiota, the characteristics of digestion, And the state of the intestinal barrier [3,4]; and (3) studies of individual responses of the Immune system to food antigens that cause changes in food tolerance and reactivity of The adaptive immune response. The adaptive immune response is provided by lympho-Cyte functions (acquired immunity) and plays an important role in the defense from in-Fection and elimination of exogenous pathogens in vivo [5–8].Food allergy is defined as an adverse immune-mediated reaction that occurs when Exposed to a food agent and disappears when it is withdrawn [9]. Other non-allergic food Reactions are intolerant and do not affect the immune system [10].

AI in Food Composition Study:

The use of AI techniques in studying the composition of food products and testing Their originality dates back to the 1990s. Dettmar et al. used the ANN technique to identify The region of origin of fruit from a set of 16 variables characterizing samples of orange Juice [23]. The effectiveness of the applied calculation technique was 92.5%. Yang et al. used the isobaric tag for a relative and absolute quantification proteomic Approach to analyze differentially expressed whey proteins in the human and bovine Colostrum and mature milk to understand the different whey proteomes. It may provide Useful information for the development of nutrient food for infants and dairy products [24]. Moreira et al. used topological maps of the Kohonen neural network in the assessment Of the procedure for sample preparation of cashew nuts [25]. Shen et al. used laser-induced Breakdown spectroscopy (LIBS), least squares support vector machines (LS-SVM) and LASSO models for the detection of six nutritive elements in Panax notoginseng (traditional Chinese medicine) samples from eight producing areas [26]. Rasouli et al. applied the whole Space genetic algorithm-radial basis function network (wsGA-RBFN) method to determine The content of microminerals of Fe^{2+}, Zn^{2+}, Co^{2+} and Cu^{2+} in various pharmaceutical Products and vegetable samples (tomato, lettuce, white and red cabbages) [27]. This group of studies also includes the research of Soltani et al. who used three different quantitative structure bitter taste relationship (QSBR) models (artificial neural network, multiple linear regression and support vector machine) to predict the bitterness of 229 peptides [28].

AI in Research on Production of Nutrients:

With regard to research on the optimization of the production of certain nutrients,Several studies have been identified in which AI modeling was intentionally applied.Huang et al. implemented methods of production of a retinol derivative named retinyl Laurate by an artificial neural network (ANN) [29]. Zheng et al. studied the optimization of Producing 2,6-dimethoxy-ρ-benzoquinone (DMBQ) and methoxy-ρ-benzoquinone (MBQ) As the potential anticancer compounds in fermented wheat germ. They used algorithms of An artificial neural network (ANN) combined with the genetic algorithm (GA) [30]. The ANN model with a Levenberg–Marquardt training algorithm was applied for modeling the Complicated non-linear interactions among 16 nutrients in this production process. Kumar Et al. used GA-Fuzzy—an evolutionary algorithm comprised of the genetic algorithm (GA) and the fuzzy logic methodology (FLM)—for the optimization of the production of Phycobiliproteins (PBPs) from cyanobacteria [31].

DIETARY ASSESSMENT:

Researchers have major challenge about assessment of Dietary intake. The evaluation of dietary intake can use Different methods such as 3 day food records, 24-h recall or Food frequency questionnaire [6]. Researchers face many challenges when deciding which Method is the best [5]. Issues of participant burden, Motivation and willingness to accurately report diet, and Participant literacy and memory should be considered.

Also, the time to enter and analyze diet data, and therefore The availability of resources to accurately analyze dietary Recalls, must be taken into account before starting a study [7]. All methods of dietary assessment have limitations. For Example, a single 24-hour recall reflects only foods Consumed in a single irregular day and may be less Representative of an estimated individual's intake. However, two or more 24-hour recall or food recording are Required to estimate normal dietary intake distributions [8]. One limitation of food records is that they can cause Awareness bias [9]. FFQs can lead to overreporting of Average dietary intakes and can rely on the participant's Ability to accurately recall portion sizes and frequencies, Similar to 24-hour recalls. Also, the FFQ may be Interrupted; therefore, its ability to stay focused can be Challenging for indices [10]. For these reasons, new dietary Assessment methods are needed for the well-being of Individuals and researchers.Tracking dietary assesment of individuals is important in Evaluating the nutritional status for both dieticians and Clients [11]. It has been observed that there is an increase in The use of artificial intelligence applications in nutrition and Dietetics. For example; the food consumption records, Which are evaluated by taking photos of the foods Consumed, are guiding in evaluating the nutritional status. These photos taken with mobile phones make the Application practical and applicable [3].

By this apps, the dietician can follow the recommended diet Plan and the clients can also control themselves to their diet Adaptation [12]. Monitoring regular food intake in Hospitalized patients plays a critical role in reducing the risk Of malnutrition associated with the disease. While various Methods have been developed to estimate food intake, there Is still a clear demand for a more reliable and fully Automated technique, as this can increase data accuracy and Reduce both participant burden and healthcare costs [13]. However, the notifications are based on self reporting is Seen as a disadvantage [12]. Other disadvantages; the visual Of foods might change while they are prepared. At the same Time, some foods may appear visually similar or the same Food may look different depending on the angle and Lightining. Therefore, the preparation process of databases In apps is very important [14, 15]. Despite these Disadvantages, these practices may contribute in the future Improvement of dietary assessment of individuals, Providing individual monitoring and positive behavioral Changes [3].

There are many apps for dietary assessment. Keenoa [Montreal, Quebec, Canada] is a smartphone imaged–based Dietary assessment app that recognizes and identifies food Items using artificial intelligence and permits editing of Food journals in real time. Unique to other apps, Keenoa is Accessed only by registered dietitians licensed to practice in Canada with the idea that dietitians are trained to identify Food items that were missed or misidentified by the user. Therefore, the advantage of Keenoa is that dietitians can Adjust the food items to generate accurate nutrient profiles Of an individual's dietary intake. Currently, the app is being Used by practicing dietitians in Canada. From a researcher's Perspective, using Keenoa to assess dietary intakes would Reduce systematic errors associated with data entry [7].

Sullivan et al. Conducted a study to evaluate a multi-Component method for capturing nutrient intake, which Used observation, photography, and an innovative Computer program. To assess reliability and accuracy, Multiple responsible employees (Res) independently Conducted nutrient intake assessments on simulated meals; Each RE's results relating to energy intake were compared To those from the other Res and to those obtained by pre-And post-meal weighing of the food items. System Efficiency was assessed by having Res perform Independent assessments on the same set of simulated Meals using either the new or traditional hospital method For which the Res had to document each food item served And then find the items in a computer database–steps that Were automated in the new method. Evaluation of this Multiple Component Method clearly demonstrates it is a Reliable and accurate technique for obtaining assessments Of patient energy intake in a hospital setting. The method Provides a detailed accounting of energy intake while Saving significant time for the healthcare team [16]. In our Country there is not any apps which evaluated by taking Photos of the foods according to our knowledge.

Artificial Neural Networks (ANNs):

ANNs as a currently widely used modeling technique in the field of AI were inspired By the structure of natural neurons of the human brain. ANNs are mathematical modelsdesigned to process and calculate input signals through rows of processing elements, called artificial neurons, connected to each other by artificial synapses. There are three types of layers forming ANNs. The input layer captures the raw data and passes them to the hidden layer. In this second layer, the learning process takes place. The results of the analysis are collected in the output layer and the output data are created. A neural network may consist of hundreds of single units. An ANN is a parameterized system that has weights as adjustable parameters. Due to the need for estimation of these parameters, ANNs require large training sets. ANNs acquire knowledge by detecting patterns and relationships between data, i.e., through experience, not as a result of programming. An ANN reveals its particular usefulness in the case of the need for modeling datasets with non-linear dependencies. In solving biomedical problems, raw data can be both literature and experimental data. In the last two decades, ANNs have been used, among others, to create an experimental decision algorithm model open to improvement, aimed at evaluating the results of biochemical tests confronted with both reference values and clinical data [8]. This technique was also used in evaluation of cell culture cross-contamination levels based on mass spectrometric fingerprints of intact mammalian cells [9]. The particular usefulness of ANNs has been proven in pharmaceutical analyses [10]. An interesting application of ANNs is the prediction of the relationship between the Mediterranean dietary pattern, clinical characteristics and cognitive functions [11]. The usefulness of ANNs has been proven in body composition analyses, which have clearly non-linear characteristics [12]. Using ANN modeling, significant benefits can be obtained in clinical dietetics. It is worth noting that the fuzzy logic methodology (FLM) can be combined with neural networks. The idea of this area of AI is to strive for greater accuracy, dimensionality and simplification of the structure. There is a possibility to create fuzzy neural networks and convert FLM-based models into neural networks.

AI in Clinical Nutrients Intake:

Among the identified studies on the application of AI in clinical practice, there is A need to distinguish those that aimed to develop systems that monitor, support and Modulate the nutrition of chronically ill people. Lu et al. presented a novel system based On AI to accurately estimate nutrient intake, by simply processing RGB depth image pairs Captured before and after meal consumption [43]. Oka et al. compared AI-supported Nutrition therapy with a mobile application (n = 50) versus human nutrition therapy (n = 50) in a randomized controlled trial [44]. An interesting technological solution in the AI area was used by Vasiloglou et al. in relation to the clinical problem of controlling Carbohydrate intake in patients with type 1 diabetes. These authors used GoCARB as a Computer vision-based smartphone system in determining plated meals' carbohydrate Content. In this study, the estimation of carbohydrate content in 54 plated meals made byGoCARB was compared to the estimation made by six experienced dietitians. It was found that GoCARB estimated the carbohydrate content with the same accuracy as professional nutritionists (p = 0.93) [45].

Chin et al. tested the Automated Self-Administered 24-Hour Dietary Assessment Tool (ASA24) on the example of lactose with regard to the Nutrition Data System for Research (NDSR) [46]. ASA24, also known as food diaries, is a web-based tool that enables Multiple, automatically coded, self-administered 24-h diet recalls. NDSR is a dietary Analysis software application widely used for the collection and coding of 24-h dietary Recalls and the analysis of menus. Nine machine learning models have been developed Based on the nutrients common to ASA24 and the NCC database. The results obtained in This study suggest that computational methods can successfully estimate an NCC-exclusive Nutrient for foods reported in ASA24.

In order to monitor eating behaviors, a rapid automatic bite detection algorithm (RABID) that extracts and processes skeletal features from videos was constructed. Kon-Stantinidis et al. used it to analyze the eating behaviors of n = 59 patients (three types of Dishes, 45 meals), the results of which showed an agreement between algorithmic and Human annotations (Cohen's kappa κ = 0.894; F1-score: 0.948) [47]. Chi et al. proposed a knowledge-based system (KBS) for patients with chronic kidney Disease using the Web Ontology Language (OWL) and the Semantic Web Rule Language (SWRL) [48]. In order to evaluate the designed system in recommending appropriate food Serving amounts from different food groups, information was collected from n = 84 patients. It was found that the OWL-based KBS can achieve accurate problem solving and reasoning Questions while maintaining the ability to share and extend the knowledge base. AI techniques can also be useful in diagnosing mild dehydration.

Posada-QuinteroEt al., using machine learning, investigated the possibility of detecting mild dehydra-Tion with autonomic responses to cognitive stress (n = 17) [49]. Taking into account the Autonomic control indicators based on electrodermal activity (EDA) and pulse rate vari-Ability (PRV) in the Stroop test, they obtained 91.2% overall accuracy of mild dehydration Detection. In the area of AI applications in the improvement of dietary solutions, two articles Describing prototype solutions should be mentioned. Khan and Hoffmann proposed a Menu construction using an incremental knowledge acquisition system (MIKAS) [50]. This System asks the expert to provide an explanation for each of their actions, in order to Include the explanation in its knowledge base, so MIKAS could in the future automatically Perform them.Fuzzy arithmetic has been used to create “Nutri-Educ”—software for proper balancingOf meals, according to the energy needs of the patient.

Heuristic search algorithms are used To find a set of actions, acceptable from a nutritional point of view, that will transform the Initial meal into a well-balanced one [51]. Baek et al. applied the hybrid clustering-based food recommendation method that uses Chronic disease-based clustering and a nutrition knowledge base [52]. Food products are Grouped using the k-means algorithm and food and nutrient data system. Based on the created Clusters and data on food preferences, a knowledge base on diet and nutrition is generated. Mezgec and Korouši´c Seljak introduced a new “NutriNet” tool for food image recog-Nition based on a deep convolutional neural network architecture [53]. It was tested on a Collection of 225,953 images (512 × 512 pixels) of 520 different foods and beverages. This Tool with an implemented training component is used in practice as a part of a mobile app For the dietary assessment of Parkinson’s disease patientpatients.

AI in Research on the Influence of Nutrients on Physiological and Pathophysiological Functions:

The most numerous group of works presenting applications of AI models in biomedi-Cal nutrients research is research on vitamins. Pavani et al. used the neuro-fuzzy model to investigate the influence of alterations In vitamin K (K1, K2 and K3) on modulating the warfarin dose requirement [32]. An AI Model was used to predict the warfarin dose, and higher vitamin K1 was observed in the CYP4F2 V433M polymorphism in this study.

The use of AI techniques in research on the influence of vitamin D on the functioning Of the human body was described in articles published in 2019. Yu et al. compared the Expression profiles of miRNAs, lncRNAs, mRNAs and circRNAs, between 1,25-(OH)2D3-Treated endothelial progenitor cells (EPCs) and control cells. They used bioinformatics Analyses to identify differentially expressed RNAs and constructed the competing endoge-Nous RNA (ceRNA) networks with Cytoscape software [33]. Zhang et al. investigated The effect of 1,25-dihydroxy-vitamin D3 (1,25-(OH)2D3) on primary chondrocytes cultured From patients with an osteoarthritis protein–protein interaction (PPI) by a PPI network [34]. They suggested that their study might provide a theoretical basis for the use of vitamin D In treating osteoarthritis.

Kolhe et al. tried to verify the hypothesis that vitamin C mediates proliferation And differentiation of bone marrow stromal cells through miRNA regulation [35]. They Performed bioinformatics analyses to identify novel target genes and signaling pathways. Gene Ontology word clouds were generated using the online Wordle software. Huang et al. investigated an influence of the active ingredients of licorice (root of Glycyrrhiza glabra) for muscle fatigue by RNA-Seq and bioinformatics analysis. They used A machine learning model and a docking tool to predict active ingredients. They identified Hispaglabridin B (HB) as a possible inhibitor of FoxO1 which was useful for preventing Muscle wasting in chronic kidney disease [36].Li et al. investigated the effects and mechanism of Ginkgo biloba L. on Alzheimer's Disease by using compound-target-disease and compound-group-target-pathway (CGTP) Network models [37].

Panwar et al. developed in silico models for predicting vitamin-interacting residues In a protein from its primary structure. They used machine learning techniques such as Various classifiers of SVM, Random Forest, , Naïve Bayes, Naïve Bayes Multinomial And Complement Naïve Bayes and position-specific scoring matrix (PSSM) features of Protein sequences to identify vitamin-interacting residues in a protein [38]. Yu et al. used A new predictor, the Target Vita web server, and datasets for predicting protein–vitamin Binding residues using protein sequences [39].

AI in Studying the Relationships between Disease and Trace Elements Levels:

In a review of AI application reports, there were identified articles examining the levels of selected trace elements in biological samples collected from patients with type 2 diabetes. Tan et al. examined the usefulness of machine learning (Adaboost) in combination with trace element analysis of hair samples in diagnosing CVD in clinical practice (n = 124) [58].The same authors examined the levels of several elements, including trace elements:lithium, zinc, chromium, copper, iron, manganese, nickel and vanadium, in whole blood of type 2 diabetes patients (n = 53), comparing them with analogous data obtained from healthy people (n = 105) [59]. In order to construct the model, they used Fisher linear discriminate analysis (FLDA), a support vector machine (SVM) and a decision tree (DT) for data analysis. In 2014, the results of the relationships between several element levels in hair/urine and diabetes mellitus (n = 211) were published using ensemble and single support vector machine (SVM) algorithms as the classification tools [60]. In addition to the use of AI techniques in the study of the relationship between the risk of diabetes and trace elements, the study of relationships between schizophrenia risk and serum levels of macro and trace elements should also be noted. Lin et al. for this purpose used samples taken from 114 schizophrenia patients and 114 healthy controls and supervised learning methods [61]. The levels of 39 macro and trace elements were examined and the best prediction accuracies were achieved by support vector machines.

Conclusion:

One of the main problems in analyzing publications on the use of AI in nutrient Research is the range of research areas to be considered. This type of research creates a Very diverse spectrum of problems. They are not limited to the field of biomedical sciences, But also apply to plant and animal breeding, including the breeding of microorganisms. The limitations which were found in the methodology of the review were dictated by the Intention to maintain transparency. Therefore, studies that directly or indirectly relate to Human health were included, excluding research on nutrients in agricultural and veterinary Sciences. The review of the publications revealed three application areas of AI technology: Biomedical nutrients research, clinical nutrients research and nutritional epidemiology.

During the analysis of the reviewed publications presenting the results of research on Nutrients with the use of AI technology, it can be noticed a little later that it gained wider Application in human health research than analogous applications in experimental research On food. This may have resulted from both some ethical concerns and psychological Resistance, as well as from the imperfections of earlier AI algorithms, which seemed not Yet ready to solve problems concerning the human body. A significant increase in the Number of publications on the use of AI in nutrients research has been recorded in the last Decade (2011–2020). Perhaps the title question from the article by Gedrich et al., "How Optimal are computer-calculated optimal diets?" [78], asked at the end of the last century Was significantly ahead of the medical professions' mentality.

The use of AI in biomedical nutrients research reflects the need for efficient analysisOf large datasets that could not be analyzed using traditional statistical methods. This applies in particular to the study of the relationship between nutrients and the functioning Of the human body and in the study of the gut microbiota [40–42]. The increasing use of AI Algorithms in this area is an expression of scientific progress and is becoming not only a Privilege, but even a necessity in the pursuit of obtaining valuable results. The possible Decoding of the gut microbiota functioning mechanisms can bring significant benefits in The form of possibilities to develop modern and very effective probiotics. The application of AI algorithms in clinical nutrients research is expressed both by Systems supporting dietary activities, diseases risks in relation to food and nutrients Patterns and supplementation research. An important issue in this research area is the Assessment of the reliability and credibility of the test results obtained using AI techniques. Another essential issue is the modification of the dietician–patient relationship in the caseOf replacing, in whole or in part, the work of a medical professional by AI systems [43–53]. The problem of trust in AI-based systems, especially in the elderly, remains open.

In the social dimension, however, with the implementation of modern technologies in Everyday activities, an increase in trust in both robotic systems and AI systems in medicine Is observed. Especially on the basis of the articles included in the review, it is possible to State potentially good-quality effects of using dietary AI systems. Comparing them with The assessment of professional nutritionists, it is worth noting that in both cases, there Were similar difficulties with regard to estimating the caloric value of some food products (e.g., GoCARB) [45]. The use of AI systems in dietary assessments enables personalized Nutrition, which in some diseases is a priority.

The development of AI systems in dietetics may lead, in the near future, to a partial Replacement of medical personnel and reducing the need for personal contact with a Nutritionist. In the face of contemporary epidemiological threats, this seems to be of Significant importance. The further dynamic development of dietary systems using AI Technology may lead to the creation of a global network that will be able to both actively Support and monitor the personalized supply of nutrients [79]. In this case, consideration Should be given to geographical and cultural differences in the management of food and Nutrients. Perhaps the development of AI in nutrients research will enable the creation Of personalized nutrition databases as a starting point for modulating daily nutrition, as Enabled by Nutri-Educ based on fuzzy arithmetic [51].

On the basis of this review, it is worthwhile to consider the possibility of creating AI systems to coordinate both biomedical and clinical nutrients research with nutritional Epidemiology. Perhaps the gut microbiota function may be an important mediator of this Kind of advanced coordination. Therefore, research on the importance of the intestinal flora Is of fundamental importance in the field of nutrients research. A significant challenge for The near future is the use of AI technology in the creation of gut microbiota biobanks for The purpose of scientific research [80]. Despite the fact that AI technologies are dynamically developing, the problem in Nutrients research is not currently obtaining more and more advanced algorithms, but the Application of those that have already been developed and are standardly used in other Fields of knowledge, and even in other areas of biomedicine. An important challenge fornutrients research is also their integration with research on the use of medical robotics. Perhaps the development and application of AI in nutrients research requires modification of both mentality and professional competences, as is already postulated in relation to the food industry [81].

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