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A Review of Artificial Intelligence Applications in Food Sciences, Nutrition and Health: A Sustainable Approach

Una revisión de las aplicaciones de inteligencia artificial en ciencias de los alimentos, nutrición y salud: un enfoque sostenible

Dr Dipali Saxena [1] & Dr Uttam Shrama[2]

[1] Assistant Professor (Food Sciences), Shri Vaishnav Institute of Home Science, Shri Vaishnav Vidyapeeth Vishwavidyalaya Indore, Madhya Pradesh, India.

[2] Coordinator, Shri Vaishnav Institute of Home Science, Shri Vaishnav Vidyapeeth Vishwavidyalaya Indore, Madhya Pradesh, India

Corresponding author: Dr Dipali Saxena & Email: dipalisaxena@svvv.edu.in

ABSTRACT

Artificial intelligence applications in food and health sciences have grown in popularity in recent decades. The capabilities of artificial intelligence (AI) in medical diagnostics, risk prediction, and therapeutic approach assistance are quickly expanding. The development of dietary systems employing AI technology may result in the establishment of a global network capable of actively supporting and monitoring the personalised delivery of nutrients. This overview can serve as a starting point for brainstorming and developing to unimagined AI applications in food science and nutrition. Artificial intelligence is a subfield of computer science that aims to mimic mental processes, learning skills, and knowledge management. AI-based methods, such as picture recognition, may help improve dietary assessment by increasing efficiency and eliminating systematic and random mistakes in self-reported dietary intake assessments. In conclusion, AI-based approaches are likely to improve and expand nutrition research, as well as aid in the exploration of new applications. Different apps, such as food preferences, food segmentation, and dietary consumption, are thought to play an essential role in health promotion. Artificial intelligence applications are expected to aid in the enhancement of health as well as the assessment and monitoring of nutritional status.

Key words: learning, processes, dietary, segmentation, health.

RESUMEN

Las aplicaciones de inteligencia artificial en ciencias biomédicas han crecido en popularidad en las últimas décadas. Las capacidades de la inteligencia artificial (IA) en el diagnóstico médico, la predicción del riesgo y la asistencia de enfoque terapéutico se están expandiendo rápidamente. El desarrollo de sistemas dietéticos que emplean tecnología de IA pueden dar lugar al establecimiento de una red global capaz de apoyar y

monitorear activamente la entrega personalizada de nutrientes. Esta descripción general puede servir como punto de partida para hacer una lluvia de ideas y desarrollar aplicaciones de IA no imaginadas en ciencia de alimentos y nutrición. La inteligencia artificial es un subcampo de la informática que tiene como objetivo imitar procesos mentales, habilidades de aprendizaje y gestión del conocimiento. Los métodos basados en IA, como el reconocimiento de imágenes, pueden ayudar a mejorar la evaluación dietética al aumentar la eficiencia y eliminar errores sistemáticos y aleatorios en las evaluaciones de ingesta dietética autoinformada. En conclusión, es probable que los enfoques basados en IA mejoren y amplíen la investigación nutricional, así como la ayuda en la exploración de nuevas aplicaciones. Se cree que diferentes aplicaciones, como las preferencias de alimentos, la segmentación de alimentos y el consumo dietético, juegan un papel esencial en la promoción de la salud. Se espera que las aplicaciones de inteligencia artificial ayuden en la mejora de la salud, así como en la evaluación y monitoreo del estado nutricional.

Palabras clave: aprendizaje, procesos, dieta, segmentación, salud.

INTRODUCTION

Healthcare and nutrition have become significantly more important in people's lives in recent years. The long-term health impacts of COVID are experienced by a significant portion of the global population, and doctors have recommended dietary and lifestyle changes to lessen those symptoms. People in other places have changed their eating habits because of increased public health awareness. However, a lot of people are worried about the long-term nutritional effects of such changes on their health and wonder if they should increase their intake of dietary supplements or more nutrient-dense foods.

In both experimental and clinical medicine, artificial intelligence (AI), a subfield of computer science, is increasingly used to simulate thought processes, learning capacities, and knowledge management. John McCarthy, a computer scientist from the United States who passed away in 2011, coined the term "artificial intelligence" for the first time in 1955 when he proposed a research project that was carried out the following year at Dartmouth College in Hanover, New Hampshire (Nilson 2010).

Artificial intelligence (AI) applications in medicine and the biological sciences have grown during the last few decades. The applications of artificial intelligence to medical diagnosis, risk assessment, and treatment procedure assistance are expanding quickly. Measurable clinical gains have been attained because of the application of AI in ophthalmological (Ting et al., 2018), radiographic, and cardiac (Yasaka etal., 2018) diagnostics.

As computing technology develops quickly, so does the underlying language processing software. The user's ailment is classified by the diet management software, which also offers a diet plan to help the user stick to their diet. The classifiers group diseases into different categories. The naive bayes classifier is the one employed in this application. The chatbot serves as the user's personal dietician and makes suggestions. Through interaction with them during a question-and-answer session, the web-based chatbot will benefit both diabetes patients and members of the general community. To begin a session, a new user must first register. Like other

mobile applications, this one will utilise user input and deliver the intended outcome. Research on novel medications has utilised AI (Hessler, G. and Baringhaus K. 2018). Research on nutrition and medical sensing technology has new prospects thanks to the development of AI (Heydarian, H.et al., 2019).

Artificial intelligence (AI) methods are increasingly being used in applications related to food and nutrition. With the growing use of smart devices and deep learning (DL) techniques, it is now possible to create AI-based food intake reporting. The use settings, food datasets, food identification technologies, mobile or wearable devices, and food datasets all play a part in this. To improve dietary evaluation, methods for identifying food items, food quantities, and food characteristics have been developed. The application technology may make tasks like food image recognition simpler.

Artificial intelligence models with a nutrition focus can aid in providing the answers to these concerns and assisting people in achieving their goals of living healthier lives with fewer chronic diseases. The current study focuses on the present and foreseeable usage of artificial applications in nutrition and food science.

1. Artificial intelligence models in field of Food Science

Segmentation for Artificial Intelligence-Based Food Identification as by Freitas et al., 2020 reported Food Identification Using Deep Neural Network Segmentation. Most identification issues are usually classification issues, where one label is reported for the entire picture. However, real-world food photography is too intricate for a single label. Multiple dishes, plates, cutlery, tables, and other scene elements may be seen in a photograph. difficulties unique to a given domain, such as high interclass similarity. Examples are the differences between various coffee varieties or cheeseburger variations (cheeseburger vs. vegan burger vs. bison burger), as well as more widespread issues like occlusion. A system that is effective should be able to get around them, precisely isolate the food items, and identify them. The determination of all the food's constituents is a more challenging task. For instance, it might be necessary to describe the primary dish in a picture as a pizza with additional details like salami, pepperoni, mozzarella, and tomato sauce. Every pixel in the image might be a different type of food, such as a vegetable or meat. Every pixel must be tagged with a food or ingredient name to achieve that level of fine-grained information. Segmentation is the word used in computer vision to describe this method of classifying each pixel. When it comes to solving the problem of food identification, segmentation provides the most effective and useful strategy.

Over the years, a lot of deep neural architectures for segmentation have been laid out. The fundamental issue that each of them must address is scaling the convolutional filter maps back to the dimensions of the input image so that each pixel in the image may receive a label. Their up-sampling strategies, layering, training results, and other features vary. Let's explore five prevalent architectures.

1. Fully Convolutional Network

Only convolutional layers make up a fully convolutional network (FCN). It does not have a fully connected layer like a conventional classification network does to integrate convolutional filter maps into a 1-dimensional vector prior to classification. Instead, even the final layers are made up of a unique kind of convolutional filter that creates labels for each pixel while scaling the filter maps back up to the dimensions of the input image.

2. SegNet

The architecture implemented by SegNet is the same as that used by many other segmentation networks. Convolutional as well as pooling layers make up the encoder part, which gradually downsamples the input image. Convolutional layers are used in the decoder section to upsample the data back to the dimensions of the original image. It varies from other networks in that it uses the concept of pooling indices to undo the effects of pooling operations, which makes it less resource-intensive than other networks in terms of processing and memory.

3. ENet

ENet is a ResNet version that enhances the flow of features across all layers by using residual connections between all layers. Enet excels at being incredibly light, making it a great model for mobile apps and light enough to run on smartphones.

4. DeepLabv3

A slightly older architecture called DeepLabv3 employs atrous convolutions for the upsampling phase.

5. Mask R-CNN

Faster R-CNN object detection network and FCN are the two networks that make up Mask R-CNN.

The population's weight has risen significantly because of the lack of food monitoring. Most people don't monitor and record their nutrition because of time constraints and hectic schedules. Few solutions are focused on nutritional monitoring, even though several computer vision solutions have been offered to recognise food photos. To aid in the automatic monitoring of a user's diet and nutrient intake, this paper describes the construction of an intelligent system that classes and segments food that is displayed in visuals.

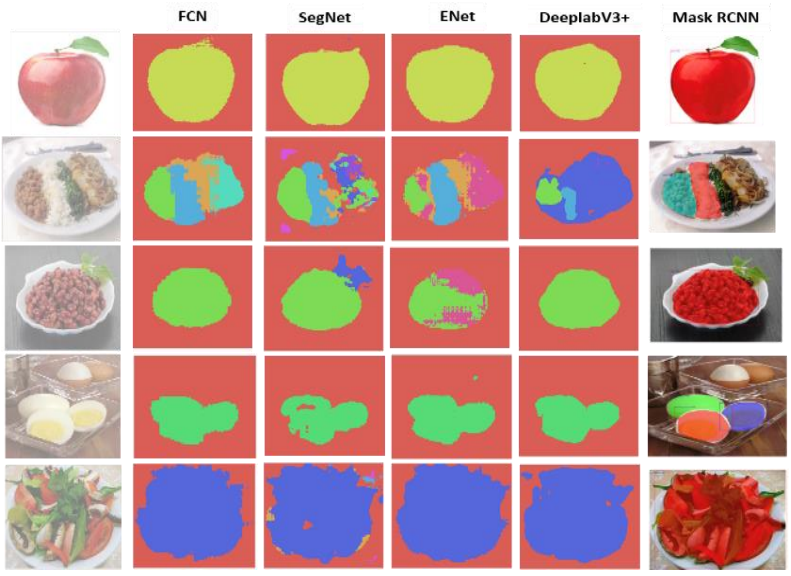

Figure 1: Food segmentation results (Source: Freitas et al.)

The segmentation outcomes for the five models on representative food items are displayed in the image above. Take note of how each one was able to keep the food apart from containers and other non-food items.

2. Dietary Assessment and Artificial intelligence

Researchers face a significant hurdle when evaluating dietary intake. Different methods, such as Three-day food records, 24-hour recall, or food frequency questionnaires, can be used to assess dietary intake (Shim et al., 2014). It is important to consider participant burden, willingness, and motivation to accurately report diet, as well as participant literacy and memory. Before beginning a study, it is also important to consider how long it will take to input and analyse diet data as well as if there will be enough resources to effectively analyse dietary recalls (Ji et al., 2020). As a result, scientists began applying AI-based strategies and methodologies to assist people in learning how to calculate their daily calorie intake from food. There are drawbacks of every dietary evaluation technique.

Dietitians and their clients should track dietary assessments of each other to assess each other's nutritional status (Hjartker et al., 2007). Artificial intelligence applications are becoming more prevalent in the fields of dietetics and nutrition, according to observations. For instance, the food consumption logs, which are assessed by photographing the meals ingested, serve as a guide when determining the nutritional status. The application is made usable and useful by these smartphone photos.

Outline the conditions for optimising the effectiveness of AI's dietary management intervention. Survival analysis and ordinary least squares (OLS) regression are used to analyse changes in physical indicators and the continuity of health promotion programmes. We discover that human involvement and specialised care must be added to AI-based interventions for sophisticated technology to be truly effective. If adding human interventions significantly raises physical indicators, a successful AI intervention would necessitate special mechanisms with extra individualised attention. The importance of remote services has increased because of the COVID-19 pandemic's confinement of individuals to their homes. Online coaching promotes healthy behaviours by fusing human and AI involvement.

By using these applications, the dietician can adhere to the suggested diet plan and the clients can also exercise self-control in adapting their diets (Burrows et al. 2019). To lower the risk of malnutrition associated with the illness, regular food intake monitoring in hospitalised patients is essential. Even though several techniques have been created to estimate food intake, there is still a clear need for a more dependable and fully automated method because it can improve data accuracy and lower participant burden as well as healthcare costs (Lu et al. 2019). Depending on the perspective and lighting, some foods may appear visually like one another, or the same item may appear different. As a result, the creation of databases for apps is crucial. Despite these drawbacks, these procedures may help advance nutritional assessment of individuals in the future by offering personalised monitoring and constructive behavioural modifications. There are several dietary assessment applications available.

3. Apps on Nutrition, dietetics, and health care

By 2025, the cost of treating chronic diseases will be a significant financial burden. Maintaining healthy eating is a crucial behaviour modification method and is frequently applied to the management of chronic nutritionally related disorders including diabetes and obesity. A successful method for minimising the harmful impacts of chronic diseases is to use smart devices to use food and nutrition knowledge for the prevention of chronic diseases. Furthermore, self-management in mobile health (mHealth) applications holds the promise of delivering dietary interventions that are both affordable and efficient.

Nowadays, there are a lot of apps in app stores with a health and fitness theme. According to Ferrara et al. (2019), there were 32,500 mobile health apps available in the major app stores in 2017. The tracking of weight management and health-related behaviours can be made easier with the help of apps (Chen et al., 2015). Additionally, new food identification systems for dietary assessment have been made possible using smartphones and the rapid development of artificial intelligence (AI) technologies. These systems are important for the prevention and treatment of chronic diseases like type 2 diabetes mellitus, cardiovascular disease, and overcoming health issues like obesity. Additionally, eating behaviour (such as calorie assessment, nutritional analysis, and eating patterns) can be analysed if food items or categories are recognized.

Reviews of numerous applications with a health focus have been undertaken in numerous studies. In a previous study, popular diet-tracking applications from the Google Play Store and Apple App Store were examined (Ferrara et al., 2019). There are 473 apps related to health, food nutrition, and dietetics available on the three main commercial app stores. (Google Play Store, Apple App Store, and Microsoft Store). These apps include "Weight Loss Coach & Calorie Counter, Nutright, Foodzilla, Nutrition Assistant, Food Diary, Recipe and Fitatu Calorie Counter - Free Weight Loss Tracker, Keto Manager: Keto Diet Tracker & Carb Counter, Health Mate - Calorie Counter & Weight Loss, MyPlate Calorie Tracker, and many others.

4. Estimate Calories and Nutrition in a Portion of Food

Many people try to pay close attention to the calories and nutrients they consume for a variety of reasons, including nutrition, fitness, weight reduction, health, physical activity, and overall well-being. Based on the daily values and portion sizes indicated on food labels, people check their intake values. They should ideally consume at levels that meet criteria established by medical organisations, such as the dietary reference intake, the recommended dietary allowance (RDA), or the appropriate consumption.

However, the ideal size of a food portion varies from person to person. According to nutrition study, most people struggle to appropriately estimate a food's nutritional value from a photo. For the sake of health and fitness, a smart system that can precisely assess the calories and nutrition in any amount of food can be highly beneficial. It can perform the role of a nutritionist by advising specialised food programmes. This method was created by fusing natural language processing with computer vision. The work Multi-Task Learning for Calorie Prediction on a Novel Large-Scale Recipe Dataset Enriched with Nutritional Information served as the

basis for this article. Sullivan et al. 2016 conducted a study to evaluate a multicomponent method for capturing nutrient intake, which used observation, photography, and an innovative computer program.

5. Status of Artificial Intelligence and Nutrition Science in India

While India has shown recent improvements in areas like life expectancy, literacy rate and health conditions, malnutrition persists in the country due to widespread poverty, rapid population growth, and weak last mile governance. That's the reason Welthungerhilfe, one of the largest private aid organizations in Germany, with support from Action Against Hunger, a global humanitarian organization that seeks to address the causes and effects of hunger and save the lives of malnourished children, decided to pilot the Child Growth Monitor app in India. The app was piloted in Maharashtra, Madhya Pradesh, and Rajasthan because undernutrition is particularly prevalent in the states and many children are affected by severe wasting conditions like marasmus.

The Child Growth Monitor project was devised to address this problem. The cloud-based, smartphone application is powered by Microsoft Azure and AI services and detects malnutrition and enables health workers identify and provide care to children struggling from chronic undernourishment. The app uses the infrared sensor available in smartphones and directly captures 3D measurements of a child's height, body volume and weight ratio, and then loads the data onto the cloud. The information is then evaluated by nutritionists and IT specialists to analyze the child's dietary health further helping the field workers to work out nutrition plans for the children. The project also reduces the treatment time which is crucial to reduce mortality due to wasting. When the app was piloted in 2018, Jochen Moninger, Innovation Director at Welthungerhilfe, was hopeful for the Child Growth Monitor app to emerge as a recognized, global solution among humanitarian organizations globally. According to Jochen, "Today, more than 800 million people around the world suffer from hunger. But you can't solve hunger if you don't know where the hungry people are."

While the non-profit had aimed to release the final Child Growth Monitor app globally in 2021, the 2020 pandemic forced them to release the beta version of the app immediately since the need to identify food insecurity and malnutrition became even more important in wake of the global health and economic crisis.

Another case study of Todsa Ashram School of Etapalli in Maharashtra recently installed an Artificial-Intelligence based machine to improve the nutrition level of tribal children of Gadchiroli. As far as the working of this device is concerned, the machine takes a picture of the student with her/his plate of food and within a few seconds without any human intervention, it identifies whether the quality of the food is good. This technology will be proved helpful, especially in cases of mid-day meals offered in government schools that often get under the radar for their poor quality. According to the news agency, the initiative was taken by the administration under project Bhamragad and there are eight government schools' part of it.

FUTURE POSSIBILITIES

The potential benefits of AI in improving maternal and child health in India are too great to ignore. One of the most promising applications of AI in maternal and child health is around predictive modelling. By analysing large amounts of medical data, AI algorithms can identify risk factors for maternal and foetal complications and predict the likelihood of certain outcomes. This can help healthcare providers to identify high-risk pregnancies early on and take steps to mitigate the risks. It is important to address these challenges and to work closely with local communities and healthcare providers to develop and implement effective AI-based solutions that are relevant, accessible, and appropriate for the local context.

Another area where AI can make a big impact is in the detection of fetal abnormalities. In LMICs, access to ultrasound technology is often limited, and the quality of images may be poor. By using AI to analyse ultrasound images, healthcare providers can improve the accuracy of diagnoses and detect abnormalities that may otherwise be missed. To maximise benefits, standardising the way images are taken, regulating the qualifications and performance of those who operate and interpret them, integrating clinical information, and providing feedback on performance will be essential.

In addition to its diagnostic applications, AI can also be used to improve access to care. Virtual care technologies, such as AI-powered chatbots and virtual assistants, can provide expectant mothers in LMICs with information and support. It has been demonstrated that sending personalised, timed voice messages about pregnancy via mobile phone can positively impact maternal healthcare practices and improve maternal health outcomes. However, more research is needed to determine if voice messaging is more effective at motivating behaviour change compared to text messaging, particularly in areas with low literacy rates. These technologies can triage patients and direct them to the appropriate level of care, helping to reduce the burden on overworked healthcare systems.

AI can also be used to manage and analyse large amounts of data collected from electronic medical records and other sources. By identifying trends and patterns in this data, healthcare providers can make more informed decisions and improve outcomes for mothers and children.

CONCLUSIONS

AI are an expanding part of our daily lives. Because so much of our lives already include AI, it would benefit health professionals to learn more about this technology and how it could be advantageous to their clients. Although additional research studies using big data sets are required to better elucidate how much AI and/or machine learning affects precision nutrition, the current focus on improving individual lifestyle and associated nutritional intake should continue. The apps to be used in the field of nutrition and dietetics should be developed by considering the disadvantages and advantages. The further apps will help both in health promotion and monitoring and evaluation of dietary assessment.

AI has the capability of bringing about a substantial difference in maternal and child health in India. Nevertheless, it is crucial to keep in mind that these innovative technologies should not be utilised as a substitute for conventional healthcare practices, but rather as an additional tool. The integration of AI with the already existing healthcare systems would bring about the best results. It is also essential to involve healthcare providers and local communities in the development and implementation process of AI-based solutions. This way, the solutions can be made more relevant, accessible, and in line with the local context, thereby, maximising their positive impact.

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