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APPLICATION OF ARTIFICIAL INTELLIGENCE ON NUTRITION ASSESSMENT AND MANAGEMENT

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ABSTRACT

Artificial Intelligence can be applied in multidisciplinary fields, including patient service and care. It enables precise and personalized medical nutrition care by assessing food and nutrient intake, nutritional evaluation. The application of AI for the provision of food services to hospitalized patients is of immense scope. This review details the various ways through which AI can be applied for the nutrition assessment. Even though commercial AI-based nutritional assessment systems are available, many do not evaluate the nutrient intake, and the data available through them were not validated. FatSecret is a commercially available AI-based food and nutrient assessment system that can evaluate the food's calorie content. Also, the major challenge posed by such systems is the availability of locally appropriate data sets. Hence further research and validation are essential in this field.

KEYWORDS: Artificial Intelligence, food and nutrient intake, hospitalized patients.

INTRODUCTION

IBM defined Artificial intelligence (AI) as "any human-like intelligence exhibited by a computer, robot, or other machines".[1] Artificial intelligence enables computer programs to learn from datasets that indicate cases and knowledge, identify substances, and help in decision-making by solving the problems. AI has a vast area of applications, including the provision of health and nutrition care.[2] Precision Medicine and personalized nutrition are the areas where AI can contribute a lot. Precision medicine uses datasets of earlier interventions using advanced diagnostics and tailoring better and economically personalized treatments. Corinne *et al.*[3] proposed to define personalized nutrition as "a field that leverages human individuality to drive nutrition strategies that present, manage and treat disease and optimize health."

Nutritional status assessment of the patients can be determined by using lab tests and general and specific nutritional assessment tools such as Malnutrition Screening Tool (MST),[4,5] Mini Nutritional Assessment-Short Form(MNA-SF), [6] Nutritional Risk Screening(NRS),[7] Short Nutritional Assessment Questionnaire (SNAQ),[8] Simplified Nutritional Appetite Questionnaire(SNAQ),[9] Generated Subjective Global Assessment(PG-SGA),[10] Nutrition Risk in The Critically Ill (NUTRIC),[11,12] Modified Nutrition Risk in The Critically Ill (NUTRIC) [11] and American Society for Parenteral and Enteral Nutrition(ASPEN).[13.14] The different datasets brought out after the application of these nutritional assessment tools include demographic data, anthropometry, and its changes, details of food and supplement intake and appetite, changes in taste and satiety, level of physical activity, metabolic demands, data concerning physical activity, Acute Physiology, Age, Chronic Health Evaluation II(APACHE II), SOFA(Sequential Organ Failure Assessment(SOFA) Score15.However, the physicians' effective use of these data to address the issue of development of malnutrition at hospitals is reported to be very low.[14] In this regard, artificial intelligence can play a more significant role in personalized nutrition and the assessment of individualized nutritional recommendations and meal plans that can improve the patients' food and nutrient intake. Furthermore, it can identify patients at risk of malnutrition and can provide advice to enhance nutritional status.

Assessment of Food and nutrient intake by using AI

Twenty-four-hour recall of food intake, food diary, and three-day food weighment survey are the globally accepted methods to assess food and nutrient intake of a person. These methods are time-consuming and require skilled persons to interview the patients and collect the data. They primarily rely on the memory of the person to be investigated.[15] Hence the accuracy of the data is minimal, especially if the person is elderly or affected with diseases that can affect memory, such as dementia and Alzheimer's disease. In such cases, provision of proper nutrition and assessment of authentic food and nutrient intake is a challenge as nutritional adequacy

safeguards well-being and lessens the functional decline due to ageing[16] and disease conditions.

Reliable and accurate food and nutrient intake data are essential to plan and assess the effect of therapeutic menus for a patient under medical care. Earlier studies reported that the reliability of the data obtained through traditional methods might be biased due to incorrect estimation of the food intake data.[17] Moreover, the data does not provide any evidence or truthfulness of the menu consumed. Yulika and Alex[18] used face recognition or a vision-based system to recognize the food items and portions consumed to solve the issue. Earlier, the technique of face recognition was applied in specific user interfaces for cell phones and was used for the development of food recognition and portion estimation.[19]

Face recognition images will form the datasets for such systems. Similar datasets of images of different fast food products enabled their standardization.[20, 21] For recipe standardization, datasets of images of food ingredients were used. The best ingredient or process technology option can be chosen using suitable automated analytical software with mathematical and statistical techniques.

The development of an AI-based nutritional assessment system for the elderly and patients require webcams placed above plate placement. The image taken by the system will be analyzed by three stages such as segmentation, recognition, and estimation of portion size.

The diagrammatic representation of the functioning of AI for Food and Nutrient intake is given in Figure 1.

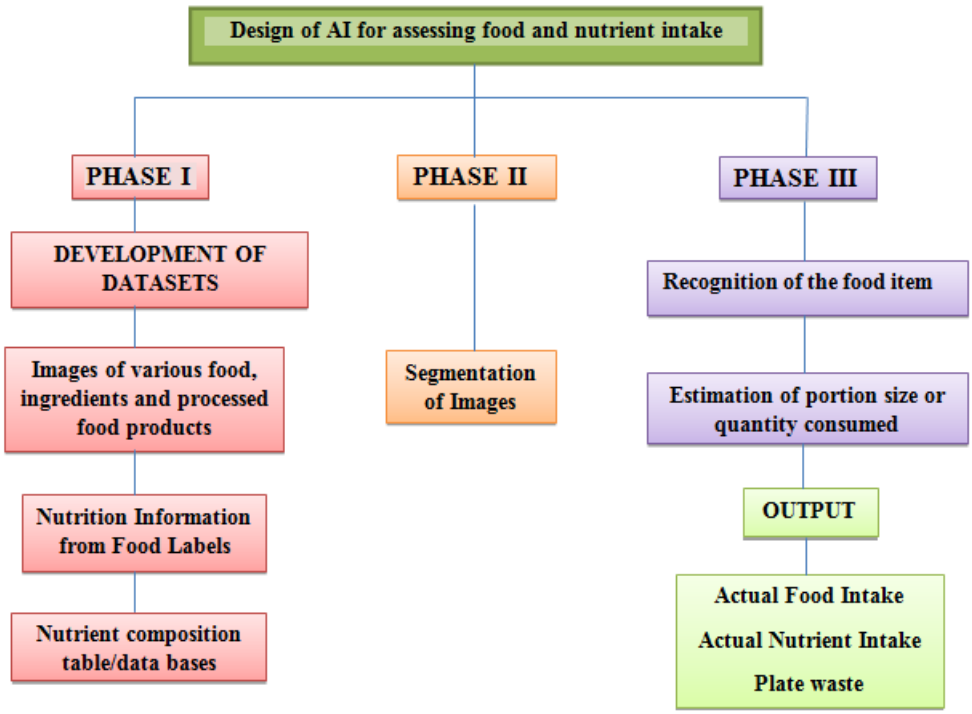

Fig.1 Process flow of design of AI for Food and Nutrient intake.

Segmentation is the process of dividing the standard input into segments to enable image analysis. The segmentation process has three stages such as classification, object detection, and segmentation. During the classification stage, the software categorizes the image into different classes. For example, the image of food items on a plate can be classified as apple, egg, bread (white or brown), butter, etc. The computer draws a rectangle surrounding the classified objects for detecting them, for example, around the apple or egg or bread or butter on the plate and around the plate itself. Later, the identified parts/segments of the object were studied by the computer, and it understands what object they belong to.

AI and nutrient evaluation of diet

Accurate dietary assessment and food and nutrient intake information may lead to healthier diets and better clinical outcomes. This is particularly important for providing nutritional care to those with obesity and diet-related non-communicable diseases. In such cases, precise evaluation of food and nutrient intake enables glycemic and lipidemic control. Miscalculations in carbohydrate intake and counting can affect the dose fixing of insulin.[22]

Furthermore, proper nutrition data is essential to manage immune-compromised conditions. Algorithms developed based on the data sets such as food and ingredient images, nutrition information from food labels, and nutrient composition databases enable the nutritional

analysis of the meal. The pictorial representation of the use of AI to calculate calorie value is given in Image 1.[23]

Such a highly accurate and fully automated nutrient estimation system requires the coordinated work of experienced nutritionists, reliable and customized food and nutrient database. Now a day, with the advancement in technology, the development and commercialization of such smartphone-based applications are available. A brief outline of such applications is provided in Table 2

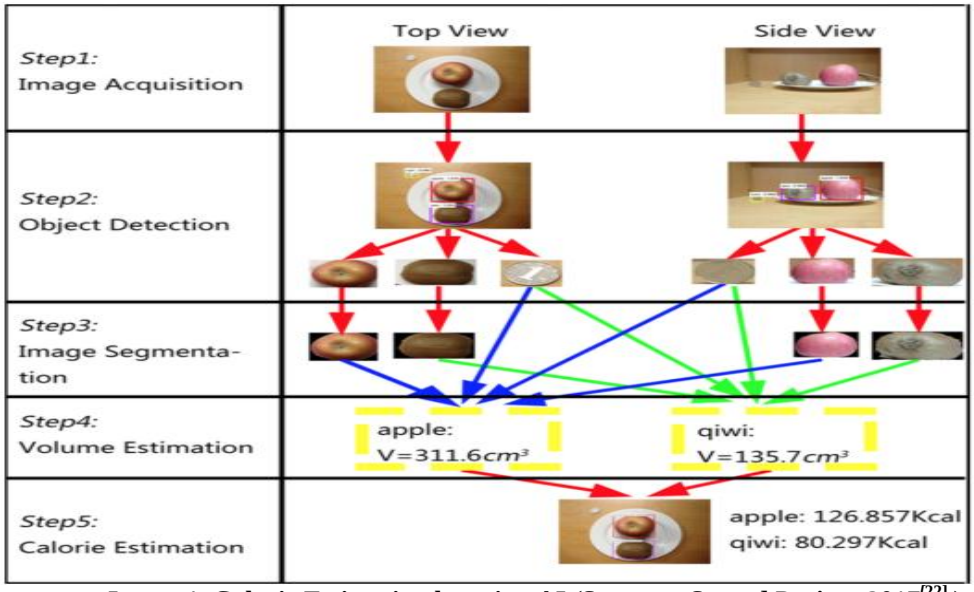

Image 1. Calorie Estimation by using AI *(Source: - Synced Review, 2017[22]).*

Table 1. Commercially available AI based food and nutrient assessment system.

Sl. No.	Name of Application[24]	Nutrients evaluated	Method of Validation of data [24]
1.	FatSecret[25]	Calories	Not validated
2.	CALORIE MAMA[26]		Not validated
3.	Bitesnap[27]		Not validated
4.	Aical[28]		Not validated
5.	GoCARB[24]		Technical Preclinical andClinical
6.	goFOOD™ [24]		Technical Preclinical and Clinical

AI and nutrition intake of Hospitalized patients

The presence of disease can increase the possibility of having or aggravating malnutrition and vice versa, which increases the risk of hospital-acquired infections, prolonged hospital stay, morbidity, mortality, and additional health care expenses. Maintenance of nutritional status by adequate food and nutrient intake is vital for early recovery.

There are possibilities that a patient may be presented to the hospital with preexisting malnutrition or malnutrition ay develop during the hospital stay. Hospital-acquired malnutrition can mainly be attributed to reduced food and nutrient intake due to lack of appetite. Sometimes, malnutrition among the patients may be developed due to incorrect food and nutrient intake assessments. The available food and nutrient intake methods at the hospital, such as food weighment,[29, 30] visual estimations [30] or digital photography[29] are either time-consuming or liable to errors resulting in drastic changes in the patient's menu. Moreover, such methods are of reduced applicability when it comes to those patients in isolation.

AI-based food and nutrient intake assessment system can overtake such barriers and enables data collection without contacting the patient trays or the patient himself. Ya Lu et al.[31] developed a fully automatic AI-based nutrient intake monitoring system for the inpatients in this context. In this system, nutrient intake was assessed by four stages performed on RGB-D (Red Green Blue-Depth) image pairs taken before and after the food consumption. The flow chart of the sequence of collection and processing the data through the four stages are depicted in Figure 2.

The system developed by Ya Lu et al.[31] effortless and contactless monitoring of food and nutrient intake of hospitalized patients and provides data for plate waste for the foodservice.

Challenges in the application of AI for Nutrition

The major challenge for applying AI-based food and nutrient intake monitoring data is that a specific program is not fit for all cuisines and meal patterns across the world. The regional differences in the gastronomy of the populations pose a real challenge in the development of

appropriate necessary data sets for deep learning Moreover, even within a region; the food items served to a patient differ from hospital to hospital. Standardization of meals served in hospitals under the same management is recommended to ease the task.

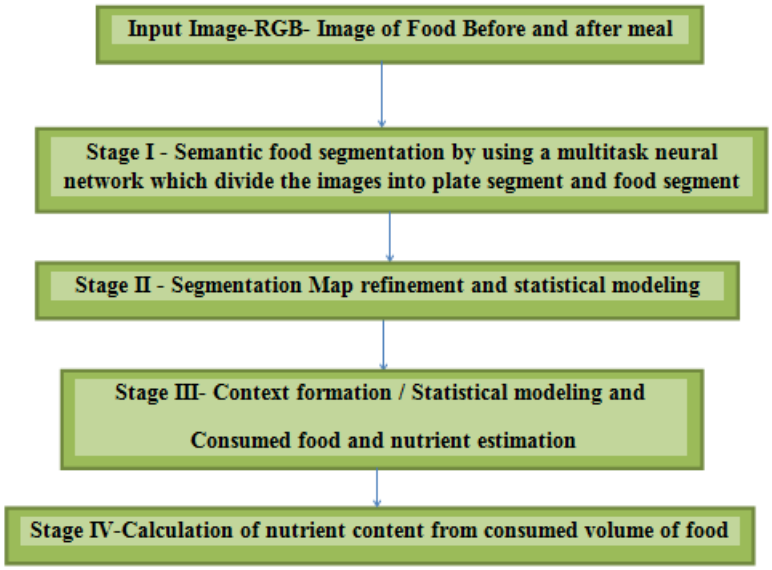

Fig 2. Outline of data collection and processing of AI based system for nutrient Intake assessment of patients.

CONCLUSION

Hospital food services are in continuous search for providing ways and means to provide high-quality patient care and service through food and nutrition service. AI-based nutrient intake assessment system is of immense value to obtain and assess food intake data in isolation wards and for the follow-up without contact. Further research and developments in the application of AI on nutrition assessment and management are recommended.

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