



NUTRINET: INDIAN FOOD NUTRITION CLASSIFICATION USING DEEP LEARNING

Nutritional Science

Dwith Chenna University of Maryland, USA.

Kanishka Macherla University of Maryland, USA.

ABSTRACT

In developing countries like India, understanding dietary patterns and nutritional values is crucial for public health and raising awareness. Numerous studies have investigated the nutritional aspects of various Indian foods. This paper presents a novel deep learning-based approach for the automated identification and classification of Indian food items, enabling large-scale analysis of their nutritional content. By providing access to nutrition analysis for the general public, this approach aims to tackle malnutrition arising from improper food intake patterns. We explore recent advancements in deep learning techniques and assess their effectiveness in addressing the complex challenge of detecting and categorizing diverse Indian foods based on their nutritional values. The lack of labeled data for Indian dishes, along with intra-class variation and non-distinct boundaries, poses significant challenges, making this a pioneering endeavor.

KEYWORDS

Nutrition, deep learning, segment anything model, dietary patterns

INTRODUCTION

India is undergoing massive changes with advancement in economic development, balancing the problems related to both overnutrition and under-nutrition. There is an increasing trend of overweight/obesity especially in urban areas[8], whereas rural areas see increased diabetes and coronary heart diseases[9,10]. Studies showing nutritional values and dietary patterns for a diverse dietary patterns of Indian food are under studies with limited data [11]. Indian food patterns include a majority vegetarian diet and less micronutrients, as part of the regular diet. Such diets dominated by cereals without nutritional diversity lead to inadequate nutrition intakes as per the Recommended Daily Allowance (RDA) standards. Data from such studies show that nutrient values for the regular diet are lower than the RDA standards recommendations.

The Nutritional value of the food is essential for the overall health of the public. Especially in developing countries, where the food intake patterns are transforming with the modern economy, it is essential to analyze the nutritional values of the food. India has been seeing significant economic growth, but this is not reflected in the nutritional level, which is apparent from the malnutrition levels [1]. Malnutrition is an existing problem in varied age groups, which significantly affects public health and result in increased mortality, chronic illness and lower standard of living. Awareness of healthy nutrition food habits are major contributing factors for maintenance of general health. Indian diversity in geography and culture[2,3,4], lends itself to a wide variety of pulses, cereals, vegetables, milk products, meat, fats and oils, which form part of a regular diet. Cereals form an economic source of energy for low income families [5], consumed in various forms through soups, green vegetables and rice. Milk and dairy products which are an important part of the Indian diet, which is the source of vitamins and minerals essential for growth and development [6]. Nutritional values and food habits awareness will help improve the quality of life for families and communities. This is an effective tool to prevent chronic illness such as diabetes, coronary diseases, over/under weight [7].

In this paper, we try to address the problem of identification and classification of Indian food using the popular and successful deep learning based approaches like Segment Anything Model (SAM) and classification model. Section 2 describes the Indian food items used in the study and their nutritional values. Section 3 talks about the implementation details of the image processing pipeline that uses deep learning methods and Section 4 discusses the results and analysis.

Nutrition

Nutrition is essential for the proper functioning of the body and plays a crucial role in maintaining good health throughout life. Nutrients can be broadly classified into two main categories: macronutrients and micronutrients. Macronutrients are needed by our body in larger quantities as they are the main source of energy and mainly include carbohydrates, proteins and fats. Micronutrients are required in smaller quantities but are vital for proper functioning and health, they

include vitamins and minerals. A well-balanced diet should include a variety of foods from both macronutrient and micronutrient categories to ensure the body receives all the necessary nutrients for optimal health. Poor nutrition can lead to various health problems, including nutrient deficiencies, obesity, cardiovascular diseases, diabetes, and certain types of cancer. For our study, we have selected a diverse set of 24 commonly consumed Indian food varieties that represent a wide range of micro and macronutrients. These food items are extensively included in the Indian diet and are consumed by a significant portion of the population.

Table 1. Different Types Of Food Items Included In The Study

Food Items	
Indian bread-naan	Chole
Chapati	Dal
Biryani	Sambhar
Uttapam	Papad
Paneer curry	Gulab Jamun
Poha	Idli
Khichdi	Chicken curry
Omelette	Fish curry
Plain Rice	potato curry
Dal Makhni	okra
Dosa	Green beans
Poori	curd

Table 2. Nutritional Values Of The Food Items Categorized As Primary And Secondary Source

Food type	Primary Source	Secondary Source (sub-category)			
		Carboh ydrates	Prot ein	Fats	Vitamins/Minerals
Indian bread - Naan	Carbs	yes		yes	Calcium/Iron
Chapati	Carbs	yes		yes	
Biryani	Protein/ Carbs	yes		yes	
Uttapam	Protein/ Carbs	yes			
Paneer	Protein	yes			
Poha	Protein				
Khichdi	Protein				A/C/Calcium
Omelette	Protein				
Plain Rice	Carbs				
Dal Makhni	Protein/ Fats	yes		yes	
Dosa	carbs				
Poori	Carbs			yes	Iron
Chole	Protein	yes			Iron
Dal	Protein	yes			K/Iron
Sambhar	Protein	yes			K/Iron

Papad	Fats				
Gulab Jamun	Carbs/ Fats				
Idli	Carbs				
Chicken curry	Protein			yes	K/Iron
Fish	Protein			yes	K/Iron
potato curry	Fats	yes			K
Okra curry	Carbs			yes	Calcium
Green beans	carbs				K/Iron
curd	Fats			yes	Calcium

Implementation

In this section, we will discuss the implementation of a complete pipeline for segmentation, detection and classification of food items in the Indian plate meal. The detections are classified into 24 types of major food items regularly found in the Indian diet and use this information to estimate the nutrition intake. The algorithm allows users to analyze nutritional values of the food in the picture and encourage healthy food practices.

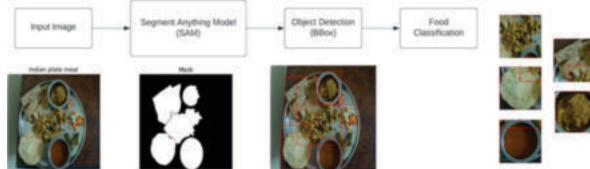


Fig 1. Overview Of The Pipeline Implementation Using SAM And Food Classification Model

Segment Anything Model

Segmentation models are a class of computer vision models used to partition an image into meaningful and semantically coherent regions. These CNN architectures are made of multiple layers consisting of (i) convolution layers to process the inputs into different feature maps (ii) activation functions to introduce non-linearity to the models, which helps with better learning/representational capabilities (iii) pooling layers to down sample the features and extract relevant information. U-Net [12] is a popular and widely used segmentation model which uses cross layer connection for better segmentation results. Recently Meta released a generalized model called Segment Anything Model (SAM), a vision transform based model, that is able to outperform many models on a variety of tasks [13]. In this section we will briefly review the architecture of Segment Anything Model (SAM). The three main components of SAM are i) Image encoder ii) Prompt encoder and iii) Fast mask decoder.

Image encoder

The image encoder model is based on Vision Transformer (ViT) [14], which is designed for real-time performance on high resolution inputs. The model is used to create image embeddings (64x64) from high resolution images (1024x1024).

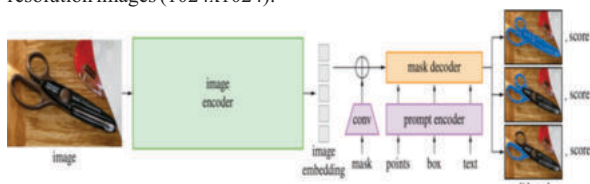


Fig 2. Segment Anything Model (SAM) Architecture [13]

Prompt encoder

The prompts take as input points, boxes, text or dense masks, which are represented through embedding using different types of encoding. The prompts are encoded into 256 size vector embedding. These mask embedding are added elementwise, if there is no mask prompt then a learned no-mask embedding is used.

Fast Mask Decoder

Mask decoder is used to map the image embedding, prompt embedding and output token to output masks. The decoder uses bidirectional self-attention and cross-attention via prompt-to-image embedding and vice-versa. It uses a dynamic linear classifier to compute mask probabilities for each location.

Food Classification

For classification of different food items we use a fine tuned ResNet50

model. We modify the last few layers to include fully connected layers with dropouts to enable representation and avoid overfitting. The input resolution of the images is 224x224, trained on a dataset of 24 major food items that are part of the regular Indian diet, as part of the Indian food classification dataset.

RESULTS

We evaluate the accuracy of the fine tuned ResNet50 model for classification of 24 indian food types. Table 3. shows the accuracy, precision, recall, f1 score metrics for the trained model on Indian food images dataset. The model is able to achieve 79.6% accuracy, overall for classification of food types. We use this trained model to identify the food types from detections based on SAM to identify food types for the ROIs and associate nutrient values to these food items.

Table 3. Summary Of Accuracy Metrics On The Model Performance On Indian Food Classification Dataset

Class name	ID	precision	recall	f1-score	Class name	ID	precision	recall	f1-score
Indian bread	0	0.8378	0.645	0.729	Chole	12	0.620	0.680	0.649
Chapati	1	0.729	0.551	0.627	Dal	13	0.758	0.941	0.840
Biryani	2	0.769	0.508	0.612	Sambhar	14	0.704	0.462	0.558
Uttapam	3	0.67	0.728	0.697	Papad	15	0.984	0.902	0.942
Paneer	4	0.918	0.777	0.8421	Gulab Jamun	16	0.839	0.723	0.776
Poha	5	0.788	0.683	0.732	Idli	17	0.897	0.813	0.853
Khichdi	6	0.876	0.825	0.850	Chicken curry	18	0.651	0.920	0.763
Omelette	7	0.622	0.634	0.628	Fish	19	0.756	0.936	0.836
Plain Rice	8	0.697	0.985	0.817	potato curry	20	0.953	0.482	0.640
Dal Makhni	9	0.850	0.904	0.876	Okra curry	21	0.852	0.763	0.805
Dosa	10	0.340	0.571	0.426	Green beans	22	0.5	0.645	0.563
Poori	11	0.793	0.924	0.853	curd	23	0.945	0.812	0.873

We test the overall performance of the system using a test set of images for Indian plate meals to evaluate the accuracy of the system. The images are taken by the user using iphone in regular lighting and of actual meals.

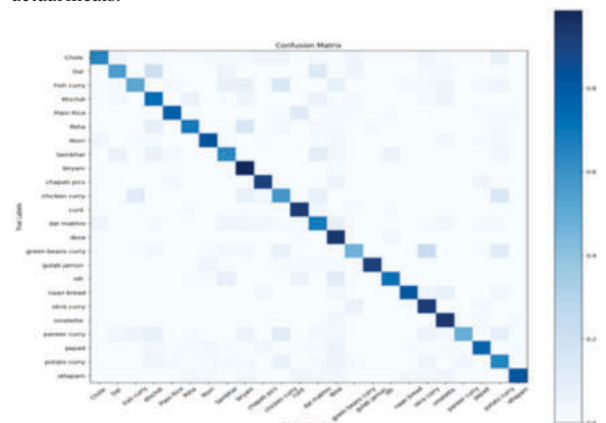


Fig 4. Confusion matrix of different Indian food classification

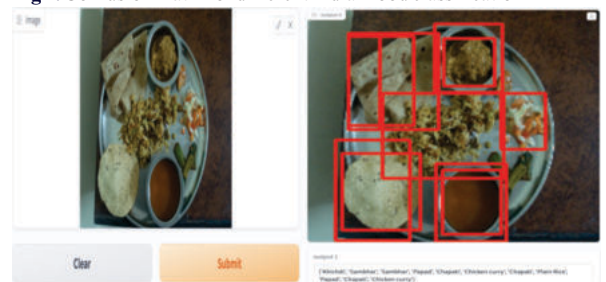


Fig 5. Implementation of the Indian Food Classification pipeline in Hugging Face[15]

This allows us to measure the accuracy of a system of realistic images. The implementation uses the SAM based detection and classification algorithms to determine the food types in the Indian meal, which helps determine the nutritional values.

DISCUSSION

We proposed a two stage pipeline to address the problem related to indian food classification, enabling the use of SOTA deep learning clearing model to address the challenges of identification and classification. The analysis shows that SAM is efficient at segmenting Indian food followed by a classification model, which shows promising results. The confusion matrix shows that certain food types have the potentially misclassified, a more curated dataset will help improve the model precision, but is beyond the scope of this study. The analysis shows promising results towards Indian food nutritional value identification using deep learning and possible ways to improve the accuracy.

REFERENCES

- [1] Haddad L. Lifting the Curse. Overcoming Persistent Under Nutrition in India. *IDS Bull.* 2009;40:1-8.
- [2] Jason RA, Aitchison JC. Greater India. *Earth Sci Rev.* 2005;72:169-88.
- [3] Basak RK. Botanical Survey of India. An Account of its Establishment, Development and Activities. New Delhi: Botanical Survey of India; 1983.
- [4] Mantovani G. Exploring Borders. Understanding Culture and Psychology. London: Routledge; 2000.
- [5] Misra A, Rastogi K, Joshi SR. Whole grains and health: perspective for Asian Indians. *J Assoc Physicians India.* 2009;57:155-62.
- [6] APEDA. Agricultural and Processed Food Products Export Development Authority. New Delhi: Ministry of Commerce and Industry Government of India; 2014.
- [7] Taylor RW, McAuley KA, Barbezat W, Strong A, Williams SM, Mann JI. APPLE Project: 2-y findings of a community-based obesity prevention program in primary school age children. *Am J Clin Nutr.* 2007;86:735-42.
- [8] NION. Dietary Guidelines for Indians. A Manual. 2nd ed. Hyderabad: National Institute of Nutrition; 2010.
- [9] Mohan V, Mathur P, Deepa R, Deepa M, Shukla DK, Menon GR, et al. Urban rural differences in prevalence of self-reported diabetes in India—the WHO-ICMR Indian NCD risk factor surveillance. *Diabetes Res Clin Pract.* 2008;80:159-68.
- [10] Shah B, Mathur P. Surveillance of cardiovascular disease risk factors in India: the need & scope. *Indian J Med Res.* 2010;132:634-42.
- [11] Venkaiah K, Brahmam GN, Vijayaraghavan K. Application of factor analysis to identify dietary patterns and use of factor scores to study their relationship with nutritional status of adult rural populations. *J Health Popul Nutr.* 2011;29:327-38.
- [12] Olaf Ronneberger, Philipp Fischer, and Thomas Brox. 2015. U-net: Convolutional networks for biomedical image segmentation. In *MICCAI*. Springer, 234-241.
- [13] Alexander Kirillov, Eric Mintun, Nikhila Ravi, Hanzi Mao, Chloe Rolland, Laura Gustafson, Tete Xiao, Spencer Whitehead, Alexander C Berg, Wan-Yen Lo, et al. 2023. SegmentAnything. *arXiv preprint arXiv:2304.02643* (2023).
- [14] A. Vaswani, N. Shazeer, N. Parmar, J. Uszkoreit, L. Jones, A. N. Gomez, L. Kaiser, and I. Polosukhin, "Attention is all you need," in *NeurIPS*, 2017.
- [15] <https://huggingface.co/spaces/cyndwith/NutriNet>.