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# Nutrient Food Prediction Through Deep Learning

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***Abstract*— The lifespan of a man can be sustained only with adequate nourishment. To lead a productive, healthy life, human needs nutritious food. In this pandemic COVID-19 situation humans need more nutritious food for combating infectious disease along with a strong immune system in our body. Nutritious foods recognition is one of the major tasks for a customer. In large stores plenty of agricultural products are stored, then there needs a classification for separating normal food and nutritious food. The real time decision will alert the consumer by predicting nutritious foods. By the use of deep learning, it may be possible to classify nutritious food along with their nutrient content and give the possible particular rating view image through the deep learning method. Enormous development in deep learning is possible due to the advancement of the Convolutional Neural Network (CNN) algorithms. CNN is a modern technique inspired by biological neurons mainly used for image processing and data analysis, producing encouraging results. The principal objective of our work is to detect and segregate normal food and nutritious food. This is accomplished using the combination of both nutrition and image Classification techniques. Hence, the proposed system achieved average overall accuracy is more than 91%.**

***Keywords*— *Food nutrient, Deep learning, Convolutional Neural Network.***

## I. INTRODUCTION

Food nutrients are present in food as micronutrients and macronutrients for growth, maintenance tissue repair and reproduction and foods are vehicles for them. An individual food may contain only a few nutrients or it may supply many, but no single food provides all nutrients in an amount and proportion necessary for adequate health. Carbohydrates, fat, protein, vitamins and minerals com-prises the general class of desired nutrients. The first three classes serve as a major source of fuel. In addition, protein supplies essential amino acids that serve as a source of utilization nitrogen for cell and tissue protein synthesis. Various foods contain different amino acids as well as protein in different amounts. In human nutrition the celluloses and other plant polysaccharide which is known as dietary fibres are not used for energy sources, but also gives gastrointestinal satiety, metabolism and health. Vitamin and minerals comprise the remaining two classes of essential nutrients. Both vitamins and minerals appear in foods in a variety of forms, the chemical nature of which may have considerable nutrient importance, since it determines whether the nutrient is made available to the body during the process of digestion and absorption. There are 13 vitamins necessary for normal growth, reproduction and maintenance of health. Their metabolic functions are diverse for example thiamine, pyridoxine, riboflavin and niacin act as coenzyme and a low dietary intake of these vitamins causes reduced activities of enzymes associated with energy transfer and utilization in amino acid metabolism. [9,12]

The mineral elements constitute the final class of nutrients to be discussed. The so-called micro inorganic elements (sodium, potassium, chlorine, calcium, magnesium, phosphorus) is present in the body in significant quantities, their combined mass being about 3kg in adult men. The micronutrients or trace minerals are required only in small amounts usually less than 30mg/day. Their body content is about 30g. The major mineral elements such as sodium, potassium, calcium, magnesium, copper, and zinc participate as catalysts in enzyme systems, and calcium, phosphorus, fluorine plays a major role in maintaining the structure of hard tissues, bones and teeth. Other essential mineral element includes iodine for formation of thyroid hormones (tri tetraiodothyronine) and iron as constituting of home as well as enzymes concerned with oxidation and reduction reactions. Dietary iron inadequately leads to low blood levels of haemoglobin.

Those all foods are categorized under the fruits and vegetables. They are divided into groups the shape, cell structure, type of seed such as berries, citrus fruits, drupes for example apple, grapes, melons, tropical and subtropical fruits. Those fruits are a very poor source of protein, fat and calorie, but a very rich source of vitamins and minerals. For cases apple and avocado are rich sources of carbohydrate and linolenic fatty acid. Apple and citrus fruits are good sources of vitamin c. All nutrients, but other non-nutritive constituent is also present in fruits as well as vegetables such as various pigments like lycopene present in tomato which gives red coloured food. Carrot rich in beta carotene that's are given orange coloured food. So, all are foods are contained not only nutritive component, but also bearing various functional group along with their nutritive components.[12]

Deep learning is a machine learning subset, which is inspired by the human brain structure known as an Artificial Neural Network, where neural network is used to extract features from the data. The Basic model of Deep Learning is CNN and Recurrent Neural Networks (RNN). CNN needs a large training dataset is basically used in image processing. CNN is a classifier derived from biological neuron. The neuron and edges have specified weights which can be updated with the help of back propagation algorithm. A complex pattern of data is learning by activation function. CNN become a popular because of its ability to solve nonlinear classification problem with encouraging results. CNN consists 3 layers as Convolutional, Pooling and Fully connected layer [1,2,4]. In this paper, CNN is used for nutrient food prediction.

## II. RELATED WORKS

In this review, we search for many food images related research works which makes the customer can detect disease, predict nutrient deficiency and food quality in various foods. A brief description of the survey is as follows.

In [2] Subit Chakrabarti, Rob Braswell, Nick Malizia, Damien Sulla-Menashe, Tina Cormier and Mark Friedl proposed a convolutional neural network (CNN) based model which predicts crop type of historical crop type data from optical and active microwave remote sensing device. Rectified Linear Unit (ReLU) is used as activation function. Sentinel-2 and Sentinel-1 having optical and micro-wave imagery is taken as a dataset for the research. From the University of Idaho researchers take weather data. Results show for major crop accuracy is 85%. Therefore, this paper can be categorized in crop prediction.

In [3] Choi Jae-Won, Tin Tran Trung, Tu Le Huynh Thien, Park Geon-Soo, Chien Van Dang, Kim Jong-Wook presented deep neural network for predicting nutrient deficiency which occurs on fruiting phrases of tomato plants. For experiment, researchers capture images to prepare a dataset for both deficiency Potassium and Calcium. For the deficiency Potassium they take 150 images for training and 55 images for validation whereas for Calcium deficiency the numbers are 140 and 40 for both training and testing dataset. Inception-ResNet v2 based CNN is used to validate the model. Results show the model gets an overall 92% accuracy. So, this paper suggests a deep neural network for predicting nutrient deficiency in tomato.

In [4] T. Mhudchuay, T. Kasetkasem, W. Attavanich, I. Kumazawa, T. Chanwimaluang proposed a deep Q-learning method to reduce rice cultivation and harvest time and increase farmer profit. Decision trees are used for classification as well as regression problems. Then a deep Q-learning neural network is used to find an efficient method for rice cultivation. For these experiments, historical data near about 10 years have taken from 52 weather stations over 878 districts in 76 provinces in Thailand. Python is used as a programming language for the experiment in which the model is trained with 75% data and for testing it takes the remaining 25% data. The experimental result shows the proposed method gives more profit compared to traditional cultivation methods. Thus, the above paper discusses methods for reducing cultivation time.

In [5] Aishwarya Chandini, Uma Maheswari studied the fruit quality detection and classification based on its extracted features from the fruit using a support vector machine for detecting the defects in fruits. Energy, contrast, correlation and homogeneity parameters were involved to extract and observe the various physical characteristics of fruit image. Images of fruit are captured and stored by a pi camera and the raspberry pi board. Both apple fruit diseases and healthy apple fruit are taken from the image dataset which are separated in the ratio 3:1 for training and testing purposes. Image processing done by using MATLAB. The proposed work obtained accuracy is 85.64%. Hence, the paper is applicable in the field of apple quality evaluation.

In [6] Atkare Prajwal, Patil Vaishali, zade payal, Dhapudkar Sumit proposed a system to detect contamination within foods. For the measurements of good quality foods, various sensor devices like Temperature sensor, Odour Sensor, PH Sensor are taken for fetching data from foods. ATMEGA328P microcontroller provides an interface for all the sensors and output produced on the LED screen. It enables evaluation and detecting the quality of food industries by analysing The Biological contamination, Chemical contamination, Physical contamination. Therefore, the paper presented a model for the assessment of food quality.

In [7] Anuja Bhargava & Atul Bansal proposed a Support Vector Machine (SVM)-based method for detection of healthy and defected apples from the image dataset. The presented model comprises three datasets with aggregate 4571 images in which 100 images taken from EOS 550D digital camera, 112 from the phone and the remaining from Kaggle. Converting of RGB image to grayscale image, “Otsu” strategy and k- means clustering are most commonly used for segmentation of the images. The proposed model achieved a superior result compared to the available system like K Nearest Neighbor(KNN), Probabilistic Neural Network, etc. Thus, this paper proposed a mechanism for detecting healthy apples using the KNN algorithm.

1: Take Emoji Diet Nutritional Data (g) - EmojiFoods (g) dataset.
2: Convert all units into a standardize unit by using several formulas.
3: Cluster all the vitamins, minerals, fats and remaining into four new attributes as gross vitamin, gross minerals, gross fats and immunity factor.
4: Calculate mean value for these new attributes.
5: Separate the whole datasets into two classes as Nutrient Food and Normal Food. If gross value of any food is larger than mean value then this food added into Nutrient Food class otherwise it added to Normal Food Class.
6: Taking images in two classes and perform rotation, Rescale, shear, shift operation for transformation and training the model.
7: Use convolutional Neural Network model.

Fig. 1. Step by step workflow of our proposed model

## III. PROPOSED MODEL

### *A. Dataset Source and Description*

Two different datasets are used for the prediction of Nutrient Food. The first da-taset used is the Emoji Diet Nutritional Data taken from Kaggle. This dataset comprises with essential nutrient minerals, vitamins, fat such as Calories(kcal), Carbohydrates (g), Total Sugar (g), Protein (g), Total Fat (g), Saturated Fat (g), Monounsaturated Fat(g), Polyunsaturated Fat (g), Total Fiber (g), Cholesterol (mg), fat, Vitamin B6 (mg), Vitamin A (IU), Vitamin B12 (ug), Vitamin C (mg), Vitamin D (IU), Vitamin E (IU), Vitamin K (ug), Thiamin (mg), Riboflavin (mg), Niacin (mg), Folate (ug), Pantothenic Acid (mg), Choline (mg), Calcium (g), Cop-per (mg), Iron (mg), Magnesium (mg), Manganese (mg), Phosphorus (g), Potassium (g), Selenium (ug), Sodium (g), Zinc (mg). [13].

$$\mathrm{EYN} = \sum_{i=1}^{19} \sum_{j=1}^{9} w_j \quad (1)$$

where wj $\in$ Carbohydrates, TotalSugar, Protein, Total Fat, SaturatedFat,

Monounsaturated Fat, Polyunsaturated Fat, Total Fiber, Fat

$$\text{Mean of EYN} = \frac{\mathrm{EYN}}{9} \quad (2)$$

$$\mathrm{BIYN} = \sum_{i=1}^{19} \sum_{j=1}^{10} x_j \quad (3)$$

where xj $\in$ Vitamin B6, Vitamin C , VitaminD, VitaminE, Vitamin K, Thiamin, Riboflavin, Niacin, Folate, Pantothenic Acid

$$\text{Mean of BIYN} = \frac{\mathrm{BIYN}}{10} \quad (4)$$

$$\mathrm{BPN} = \sum_{i=1}^{19} \sum_{j=1}^{11} y_j \quad (5)$$

where yj $\in$ Choline, Calcium, Copper, Iron, Magnesium, Manganese,

Selenium, Zinc, Phosphorus, Potassium, Sodium

$$Mean\ of\ BPN = \frac{\mathrm{BPN}}{11} \quad (6)$$

For the proper nutrient measurement, we perform several transformations between units like IU to mg, ug to mg, etc. Then cluster all the vitamins, minerals, fats into three gross values. In total there are thirty essential nutrients used as input features for the classification of foods. By the use of nutrient mineral, vitamins some equations are given to predict and distinguish various functionaries' nutrients like energy yielding, body immunity boosters and body protecting nutrients also. We form a new column named as Energy yielding Nutrient is the summation of protein and all fats, Body Immunity yielding Nutrient in which total weightage of vitamins is calculated, Body Protecting Nutrient where total Mineral is calculated those are formulated in equation (1,3,5). Then its mean value of all newly formed variables is calculated is shown in the equation (2,4,6). Then the modified dataset is divided into two classes according to the mean value of all newly formed variables. Over here the sum value of total carbohydrates, proteins and fats are greater than the mean value of those nutrients, so they fall under the energy yielding nutrients. Same as the sum value of vitamins and minerals are greater than the mean value than they are falling under the immunity yielding nutrient and body protecting nutrient. Table 1 shows the classification of foods.

TABLE I. CLASSIFICATION OF FOODS

| Nutrient Food | Normal Food |
|---|---|
| grapes | melon |
| lemon | watermelon |
| banana | green apple |
| red apple | peach |
| pear | eggplant |
| cherries | pineapple |
| strawberry | |
| kiwifruit | |
| tomato | |
| avocado | |
| potato | |
| Corn | |
| chestnut | |

## B. Input Food Database Creation

We have taken images of the classified food from Kaggle named as Fruits 360. From this dataset we calculate nutrient value for each food. According to nutrient value we classify the foods into two classes as nutrient food and normal food. For image recognition we took images of the classified food from Kaggle named as Fruits 360 dataset[14]. Fig.2 and Fig.3 shows food which is taken for the Nutrient and Normal dataset.

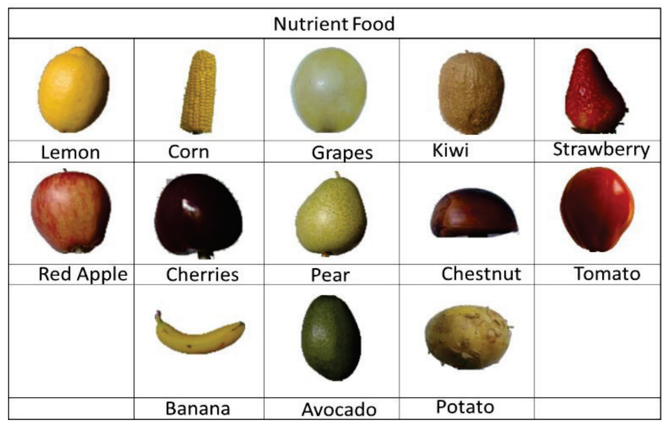


Fig. 2. Nutrient Food

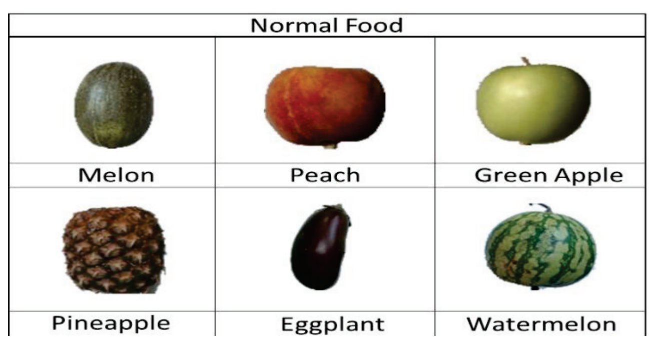


Fig. 3. Normal Food

## C. Dataset Processing

Dataset processing was performed just before model construction. The process involves various steps that include rotation, shift width and height, rescale, shear, feature selection, and transformation and classification. We scaled the dataset images to 150X150.

### D. CNN Architecture

The convolution neural network is an example of deep learning technology, which is often used in the application area of pattern recognition and image recognition. Convolution neural network models have more hidden layers with convolution and pooling operations, which makes the model higher efficiency in image processing.[15] Artificial neural network (ANN), also known as a feed forward neural network, forms an interconnected artificial neuron group that takes mathematical or computational models for information processing. Nowadays, Convolutional Neural Networks (CNNs) and other deep learning algorithms have achieved tremendous success in image detection and recognition. [8, 16] The main proposed algorithms are included training dataset creation, training the model, image detection, building food prediction model.

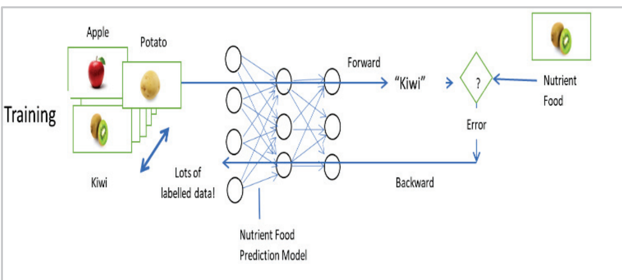


Fig. 4. CNN model for Nutrient Food Prediction

A CNN-based method is proposed for Nutrient food detection. First, classification of the image dataset is done by evaluating the gross nutrient value of each food. Then, CNN is trained with the image dataset extracting food objects such as shape, texture, and color. Next, the prediction of 19 different food images is performed using the trained CNN. The experimental results give effectiveness of the proposed model with approximately 95% and 91% of quality rates in detection nutrient and normal food respectively.

TABLE II. LAYER DESCRIPTION

| Layer type | Kernel size | Filters | Param |
|---|---|---|---|
| Convolutional | 3x3 | 32 | 896 |
| Max pooling | 2x2 | 64 | 0 |
| Convolutional | 3x3 | 64 | 18496 |
| Max pooling | 2x2 | 64 | 0 |
| Convolutional | 3x3 | 64 | 36928 |
| Max pooling | 2x2 | 64 | 0 |

In our work we use CNN for Nutrient Food prediction. Our model comprises 8 layers which include Convolutional Layers, MaxPooling2D layer, Dense Layer. To reduce the dimensions of the feature maps and the number of parameters to train the model we used Max Pooling layers. To train the model we scaled the images to 150 x 150. In The very first conv2D layer we took 32 filters, then in we took 64 and finally 64 filters were taken. The kernel size is 3x3. In total 30357 images are features used as input to the prediction model. Out of these, 75% is used for training the model and rest 25% is used for independent tests. The CNN model back propagation algorithms for training are used for classification shown in Fig.4. Table 2 shows different layer used in our model with a number of filters and parameter in each layer. In this experiment total 875,777 parameters are used. In the last output layer, we have taken the sigmoid activation function.

## IV. EXPERIMENT

The machine used to generate the benchmarks was an Intel Core i7-10th generation 10750H@2.60GHz, 16 GB RAM 2667 MHz, Graphics - Nvidia 1650 with 4GB memory, SSD - 512 GB , HDD - 1 TB. For the experiment, we used Anaconda Navigator, a desktop GUI with most common libraries for scientific Python work. We write down our programming code on Jupyter Notebook, an open-source web application. We tried some experiments with using TensorFlow, keras, matplotlib, OpenCv, etc. library in order to predict the images according to their classification.

## V. RESULTS

This section discusses the results obtained after applying our proposed model on the modified image dataset from Kaggle. Fig.5 depicts some correctly classified examples. Python was used to construct the algorithm. The various parameters set for the experiment were as follows: epochs=30; Layer: 8; activation = Relu, sigmoid; optimizer=adam; loss= binary_crossentropy; class_mode=binary. As a conclusion, it could be said that the proposed methodology showed nutrient food detection accuracy is in between 90%-99%, whereas the normal food detection is in between 85%-95%.

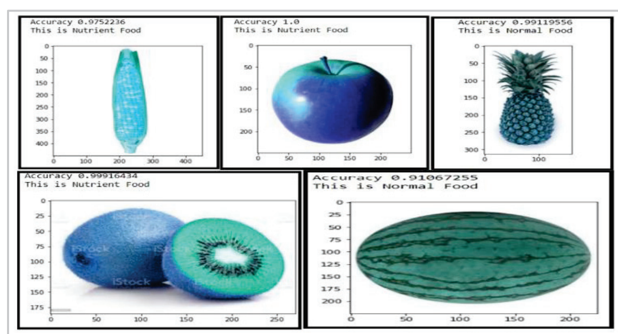


Fig. 5. Result of Food Prediction

From Fig.6 we can see the accuracy level during training of the model. It can be seen that the accuracy level gradually increases after the first 5 epochs and it almost reaches 95%.

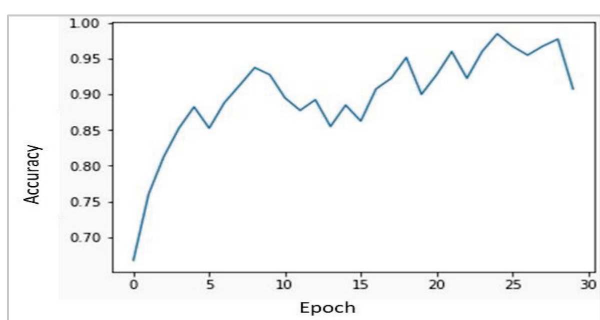


Fig. 6. Accuracy over Epoch

## VI. CONCLUSIONS

In this paper, we proposed a model for healthy foods analysis and detection. A human food quality inspection and assessment of healthy foods is often a labour intensive, monotonous, iterative and subjective assignment. We analyse a modern, effective and complex database of images with fruits. The research work performance has relevance to the real-world classification of foods and it unites both image recognition and nutrient classification techniques. The main aim for the future work is to improve the accuracy level of the Convolutional neural network by using more images for both training and testing. The result of our proposed research work indicates that our model performs quite satisfactorily. It is better to have more images for trained the model. In future we will try to use larger dataset to predict good quality, healthy foods for the needs of the food industry.

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