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Machine Learning-Based Approach to Food Recognition and Nutrition Estimation

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Abstract: Nowadays, a consistent intake of healthful foods is required to maintain a balanced diet and to avoid obesity in humans. In this research paper, we introduce a unique machine learning-based system that automatically performs accurate food image recognition and predicts food qualities. In the training stage of the prototype system, this research proposes a deep learning model consisting of a convolutional neural network that classifies food into specified categories. The proposed method's major goal is to increase the pre-training model's accuracy. The paper proposes a client-server model for a prototype system. The client sends an image detection request, which the server processes. The prototype system consists of three main software modules: a pre-trained CNN model training module for classification, a text data training module for attribute estimate models, and a server-side module. We have done experiments with a range of food options, each with hundreds of photos, in order to improve the categorization accuracy through a machine learning training system.

Keywords: Food Recognition, Estimation of Nutrition, Machine Learning, Convolutional Neural Network

Introduction

Food calorie counting is in great demand because people are becoming more concerned with maintaining a healthy weight, eating wisely, and preventing obesity. According to the World Health Organization, more than 110 percent of the world's adult population is obese. Obesity is a medical disease in which an excessive amount of body fat has been collected to the point where it may be harmful to one's health [1]. We can say that a person is growing obese if the amount of food he consumes on a daily basis exceeds the amount of energy he expends. Obesity and being overweight are linked to a slew of serious and chronic illnesses. Obesity was formally recognized by the American Medical Association in 2013 as a disorder with substantial health implications that require medical treatment [2]. As a result, daily intake assessments are critical for normal people who want to lose weight and maintain a healthy diet and weight. Only by measuring daily food consumption in a timely manner can obese people lose weight in a healthier manner, and healthy people become healthier. The traditional technique is based on a study of the user's food intake over the previous 24 hours, and while the clinical presentation has certain benefits, these methods frequently cause the user to forget about the patient's discomfort or announce that the user does not want to utilise these programs [3]. As a result, researchers have abandoned traditional clinical procedures in favor of simpler, computerized methods of calculating daily calorie estimates. The proposed approach will enable people to plan adequately for their daily calorie intake, not just fat people but also healthy ones. The following are the methods in which we will contribute to this thesis.

- We offer a novel method based on transfer learning that performs automatic precise classification of food images and calculates food properties.
- We give the dataset for evaluating the current system as well as other deep learning-based recognition systems in the future.
- Because there is no publicly available data set that includes subcontinental foods, we produced a new set of data that encompasses both subcontinental and other typical cuisines.

Pre-Trained Model Selection

Our proposed methodology is divided into three components in this section. The first section is about transfer learning-based CNN models, the second section is about text recovery from various sources, and the third section is about text data training.

Pre-Trained Convolutional Neural Network Model

On machine learning, a pre-trained network model is used to solve the problem of the system becoming trapped in a local solution during its training period. These models can do machine learning to adapt quickly to a variety of data. A CNN model employed in our proposed approach of transferring learning-based food recognition and extraction features uses a variety of food items from our provided dataset to extract distinct attributes from an object [5].

Dataset Preparing and Per-processing Phase

We categorize each image into its matching class to collect the required attributes from the photographs of various foods we assign for our research. To accomplish this, we use a variety of features to distinguish each class. The text data we collect from the internet for our study is about 1.8 GB in size. To collect data, we employed two completely distinct frameworks. The first is Common Crawl [6], while the second is Scrapy [7]. Using Scrapy, we acquired roughly 100 MB of data, while using Common Crawl, we collected 1.7 GB.

Textual Data Model Training

Word2Vec is a machine learning tool that assists us in calculating the vector representation of various words. Word2Vec is a two-layer neural network that is utilized as a replacement for the clustering technique since World2Vec is a far more powerful algorithm [10]. We utilised word2vec, continuous Bag of words, and skip Gram to train text data in this study.

We classify and divide the qualities according to our requirements before extracting attributes and ingredients. When determining the distance between qualities and ingredients and their appropriate classifications, this classification and division come in handy. The approach we use to find the distance between attributes and ingredients is to fix the food class and then iterate all attributes and ingredients against it. The food is referred to as an attribute, and the food item is referred to as an ingredient in this context. We can extract attributes and ingredients from the trained word2vec model in this way.

System Design and Implementation

This section outlines the system design, flow, and implementation, as well as the outcomes and evaluation. The goal of this demonstration is to highlight the components, flows, and tools that we utilised to build our system, as well as how they worked together to achieve the required results and features.

Architectural Overview

The server-side architecture was all that was employed in the system that we designed. The primary goal of our system is to improve the accuracy of pre-trained models so that developers and architects may use it to create their own web-based and Android-based client applications.

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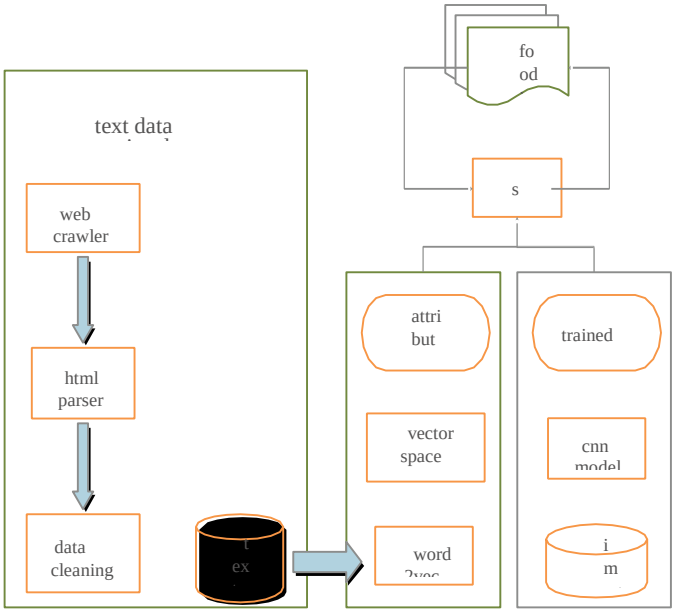


Figure 1 shows three modules: text data retrieval, text data training, and CNN-based classification model training.

After that, it was put via the Lemmatization and Stemming method. All of this textual data is combined to form a text corpus, which will be used as the input for our next text data training module. Following the extraction of the text corpus, the text data will be trained using the word2vec tool.

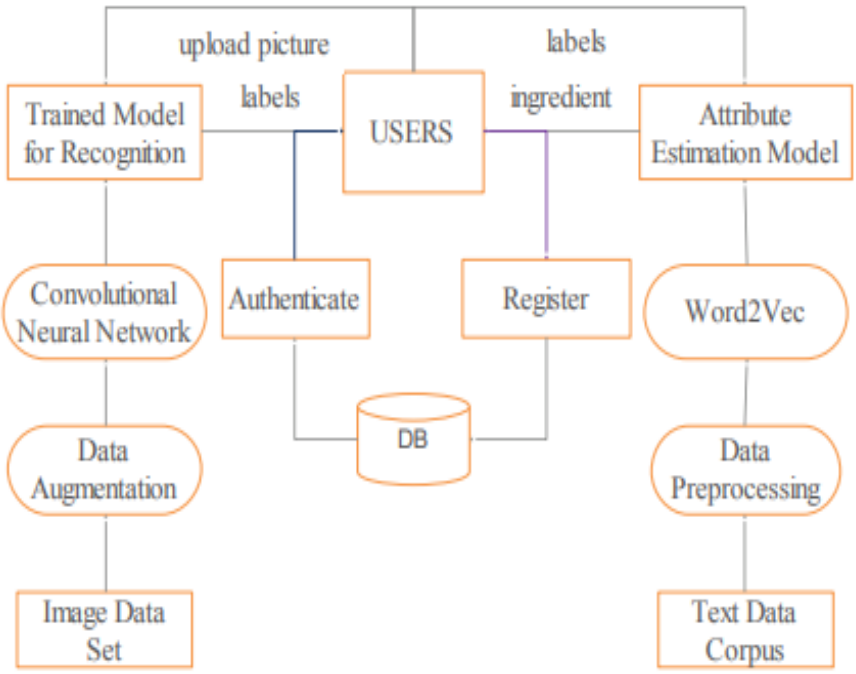


Figure 2. Dataflow diagram of proposed system

Figure 2 illustrates a CNN model that was trained on food images and related features.

The yielded label from the prior step is used as an input in the attribute estimation model. The raw text serves

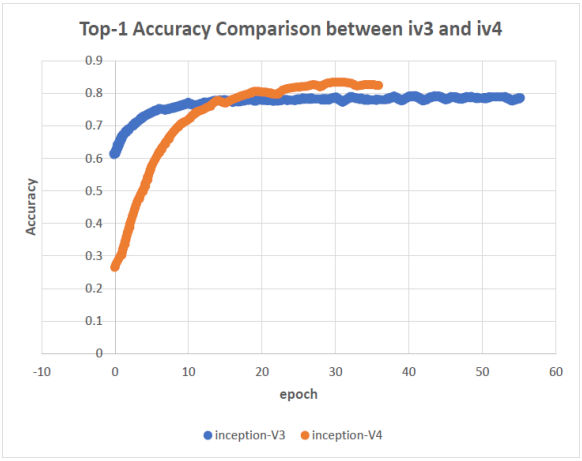
as the starting point for attribute model construction. A method known as "Word2Vec" creates vector embeddings using distance values after preprocessing textual data. Using the attribute estimate process, these data are used to produce linked ingredients or characteristics.

System Implementation

As previously said, before we can classify the images in our dataset, we must first train our system. We are employing a Linux-based operating system to create the environment. We need to install the Anaconda python distribution, as well as Python 2.7 and 3.6 before we can set up the Anaconda environment. We use the following commands to install Anaconda [11]. We'll use commands to build two environments with Python 2.7 and Python 3.6 once Anaconda is installed. We'll use the command to activate the environment after it's been constructed. We will install the essential packages of Theano, Pygpu, and Keras inside the environment files after the environment has been initialized [12]. We will now finally implement the system after the environment has been successfully completed.

Results and Evaluation

We chose the CNN model based on Inception-v3 and Inception-v4 since it outperforms other models on the issue area we suggested. In order to do a comparison, these models are fine-tuned using our own developed datasets as well as Food-101 datasets.



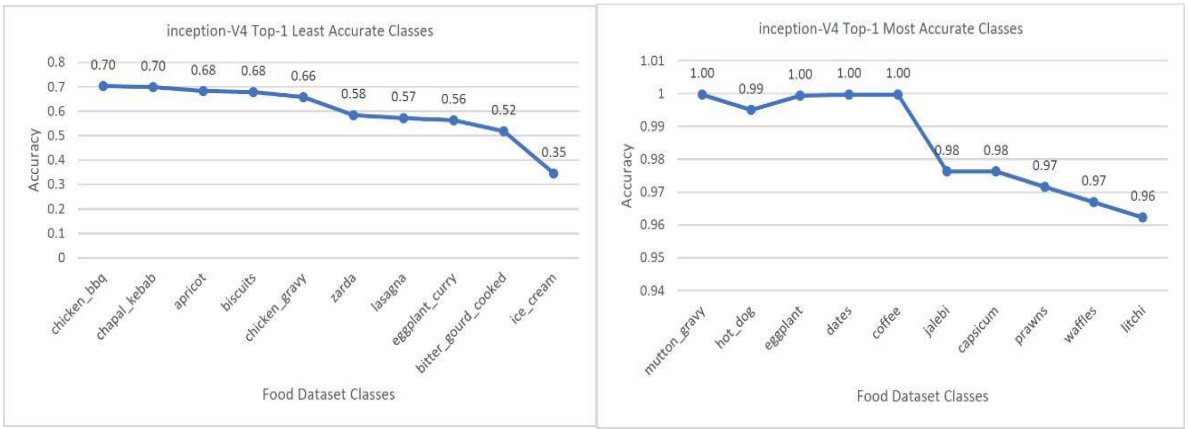


Figure 3. (a) Top-1 most accurate of inception-v4 model; (b) Top-1 least accurate class

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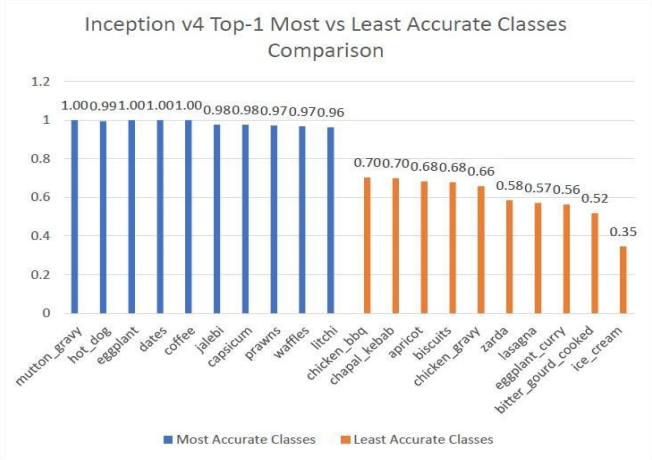

Figure 4. Comparison of top-1 most vs least accurate classes

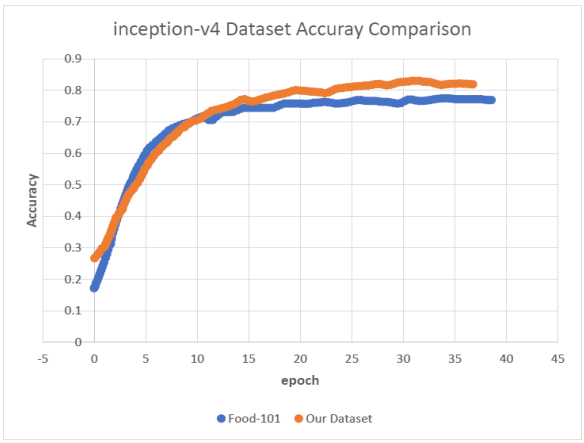

Figure 5. (a) Top-1 accuracy comparison; (b) Inception-v4 model based performan

Negative aspects and enhancements

In this section, we will explain the drawbacks current and improvements as future work.

Recognition and Detection of various food

Mixed physical representations are difficult for current systems to recognise and handle well. Foods that have been cooked, liquids, and composite items like sandwiches and salads are not included. In order to solve the issue of oblique edges or each other causing recognition detection to fail, future study will process a mixed food image and a physical image that resembles cooking using image segmentation algorithms.

Enhancement of Systems and Datasets

Mixed physical representations are difficult for current systems to recognise and handle well. Foods that have been cooked, liquids, and composite items like sandwiches and salads are not included. In order to solve the issue of oblique edges or each other causing recognition detection to fail, future study will process a mixed food image and a physical image that resembles cooking using image segmentation algorithms.

Calories Awareness and Nutrition aware

It is critical to comprehend calorie calculations and their significance. Literature [13] employs game approaches to gain more informational meals and calorie numbers, while literature [14] analyses the challenges in the field based on a simple fast food questionnaire. It can be enhanced by providing new calories to evaluate nutritional features and combining with deep learning techniques to better nurture the basic awareness of calorie calculations among users.

Conclusion

Currently, obesity is a big problem in human life. People are interested in learning how to monitor their weight and eat healthily to prevent being overweight. As a result, this research presents a cutting-edge system that offers details on the kind of food we eat as well as its properties. This system captures a picture of the user's meal and, after correctly classifying it, provides information about the food's properties.

We employed a dataset in our system that includes our subcontinental food and a typical Dish-101 meal. An attribute estimate model has been created to quantify the attributes of the food, and the Inception V-3 and V-4 models have been improved to recognize food items. Improved methods include data augmentation, multi-cropping, and other techniques.

We've also discussed potential enhancements and future work to increase the system's usability and accuracy.

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