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APPLICATION OF DEEP LEARNING IN FOOD

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ABSTRACT

With a significant number of successful examples in image processing, voice recognition, object identification, and other areas, deep learning has shown to be an advanced technique for big data analysis. It's also being used in food science and engineering recently. This is the first review in the food realm that we are aware of. We gave a short introduction to deep learning in this article, as well as comprehensive descriptions of the structure of several common deep neural network designs and training methods. We looked at hundreds of papers that utilized deep learning as a data analysis technique to address issues and difficulties in the food domain, such as food identification, calorie estimate, fruit, vegetable, meat, and aquatic product quality detection, food supply chain, and food contamination. Each study looked at the particular issues, datasets, preprocessing techniques, networks and frameworks utilized, performance obtained, and comparisons with other popular solutions. We also looked at the possibility of using deep learning as an enhanced data mining technique in food sensory and consumption studies. Deep learning surpasses other techniques such as manual feature extractors, traditional machine learning algorithms, and deep learning as a potential tool in food quality and safety inspection, according to the results of our study. Deep learning's promising achievements in classification *and regression issues will spur further study into using deep learning to the area of food in the future.*

KEYWORDS: *Computer Vision, Deep Learning, Food Quality, Food Recognition, Spectroscopy.*

1. INTRODUCTION

Human health depends on a balanced diet natural goods have long been used as food, and they may be treated to suit customer demand. Types, compositions, nutrients, and processing methods of food (both natural and processed) are all important considerations for a balanced diet. It is true that people from various parts of the world eat in different ways. It is critical to understand food characteristics (types, compositions, nutrients, and processing methods, for example) in order to check food quality and safety for consumers all over the globe.The ability to determine food characteristics quickly, accurately, and automatically is a practical need in everyday living [1]. Food characteristics have been detected using modern methods such as electronic noses, computer vision, spectroscopy and spectral imaging, and so on. These methods can collect a significant quantity of digital data on food characteristics. The importance of data analysis in these methods is critical since the huge quantity of data contains a lot of redundant and unnecessary information. How to deal with such a huge quantity of data and extract valuable characteristics from it is a pressing and essential problem, as well as a difficulty when it comes to putting these methods into practice (APP).

To deal with the large amount of data, many data analysis methods have been developed, including partial least squares (PLS), artificial neural network (ANN), support vector machine (SVM), random forest (Bossard, Guillaumin, Principal component analysis (PCA), wavelet transform (WT) (Ma, 2017), independent component correlation algorithm (ICA), scale-invariant feature transform, and speedup Various techniques have shown to be very useful in dealing with these types of data [2]. Deep learning has been widely studied as an effective machine learning algorithm and is now attracting more attention from a variety of fields, including remote sensing, agriculture production, medical science , robotics, and healthcare (Miot Deep learning has shown substantial benefits in automatically learning data representations (even for multidomain feature extraction), transfer learning , handling huge amounts of data, and achieving improved performance and accuracy. In majority of the examined papers, convolutional neural networks (CNNs) and its derivative algorithms have been identified as important techniques for automatically learning deep characteristics of input digital material for future classification or regression tasks. CNN can effectively handle the vast quantity of data produced by food quality and safety assessment equipment (spectroscopy, electronic nose, digital cameras, and so on). CNN has been shown to be successful in picture analysis (two-dimensional data), and has since been extended to one-dimensional and three-dimensional data to handle more varied data formats [3].

Deep learning is now being used in the food industry to analyze RGB and spectra pictures of food. However, since comprehending and implementing deep learning is a tough task for academics and employees in the food sector, researchers are working on it. The goal of this study is to give a thorough review of recent research development in the APP of deep learning in the food sector, as well as to provide advice to researchers and employees in this field. A brief overview of deep learning Machine learning has been used in a variety of areas as a useful tool for data processing. Traditional machine learning methods are typically complemented with a human feature extraction method due to the inability to evaluate raw natural data [4]. Machine learning capabilities may be enhanced by adding more sophisticated structures to accomplish deep data representation as hardware processing and storage capabilities improve. For detection, classification, or regression, a computer may use representation learning to extract features from raw data. Deep learning is a kind of representation-learning technique that uses a deep ANN comprised of many layers of neurons to improve multilayer representation (nonlinear modules).

Many difficult issues can be addressed quickly and effectively because to the deep learning method's high feature learning capabilities. Deep learning models show impressive skills in classification and regression problems when sufficient data support is given that accurately reflects the issue. Deep learning is beginning to be used in the area of food science, mostly for food category identification, fruit and vegetable quality detection, food calorie estimate, and so on, thanks to its great capacity of automated feature learning. In the section "Deep learning applications in food," we'll go over everything in depth. CNN, which consists of a number of components (convolutional layers, pooling layers, fully connected layers, and so on), is one of the most widely used machine intelligence models for large data analysis in a variety of fields. Figure 1 shows a typical CNN model design for classification tasks. Convolution operations are carried out by traversing input matrices using convolution kernels, which may be thought of as feature extraction filters [5]. Unlike filters used in traditional image processing methods, where the parameters must be manually specified, the parameters within the kernel may be learn automatically using deep learning. Convolutional layers are made up of a collection of convolution kernels, each of which has its own set of parameters (channels, kernel size, strides, padding, activation, and so on) that should be adjusted and optimized for the specific issue at hand. Pooling layers subsample the calculated output from the convolutional layer. High-level features representing the original input may be learned using a set of chained convolutional layers and pooling layers. The fully connected network (FNN) block, which is made up of completely connected neural units, is often employed as a classifier or to produce numerical output for regression problems that utilize the learnt feature map.

1.1 Application of Deep Learning In Food

Diets and eating habits may have an impact on human health. Diabetics, allergic individuals, and others, in particular, should keep a close eye on and manage their eating habits. Food categorization and identification are essential tasks that assist humans in keeping track of their regular meals. Food images are one of the most significant sources of information on the qualities of food. Furthermore, for food appearance analysis, image sensing is a very simple and low-cost information collection method. The vast differences in food form, volume, texture, color, and components make food identification a difficult job for natural goods like food and processed food. Food identification and categorization are also affected by the backdrop and arrangement of food items. Image analysis is now the most often utilized pattern in food identification and classification, because to the widespread usage of CNN. *Calorie Calculation for Food*: Dietary health has become more important as living conditions have improved. Many individuals are interested in keeping track of their daily diet in order to better regulate nutrient intake, reduce weight, manage diabetes or food allergies, and improve dietary habits in order to stay healthy [6]. One of the most worried indices is food calorie. Many smartphone APPs have been created for tracking daily meals, which include not only item names but also calorie information created calories, a smartphone app that estimates food calories from pictures. The system's functioning may be broken down into five stages., the CNN models and training procedures for each component are detailed. To begin, a fine-tuned Google Net CNN model was used to determine whether or not the picture recorded was food. Second, to identify the meal, a fine-tuned Google Net architecture was used.

- *Vegetable Quality Detection*: Because vegetables are high in vital nutrients, they are an important component of a balanced diet. Vegetables are susceptible to pests, infections, mechanical damage, and other impacts during production, transit, storage, and sales, all of which decrease their economic worth and may harm customers' health. Used the SAE technique (2018). They created a classification method for cucumber flaw identification based on hyperspectral imaging that integrated the stacked sparse autoencoder with CNN. The size and color variety of cucumber surface imperfections complicates the identification technique based on the average spectrum of the whole sample. As a result, using a search window spanning the whole picture, a CNN model was initially utilized to filter out the defective areas based on the image in RGB channels. The mean spectra of the defected area were input into a stacked sparse autoencoder (SSAE) for deep feature representation and classification if the region within the search window was deemed to be defected. The mean spectra of the whole spectrum picture, on the other hand, were utilized. With 91.1 percent accuracy, the proposed CNN-SSAE model beat the single SSAE system, which used the mean spectra of the whole defective cucumber as the input.

- *Fruit Quality Detection*: Fruit, like vegetables, is an essential source of nutrition for humans. Fruit production and sales face the same issues as vegetable production and sales, such as pests, illness, bruises, and so on. Additionally, fruit is a high-value agricultural commodity. Fruit freshness, nutritional content, and safety assurance are additional factors to consider. Fruit and vegetable quality detection is a popular and difficult research topic right now. Deep learning combined with image processing or spectral sensing has been extensively utilized as an effective and nondestructive fruit quality detection technique to address issues including variety categorization, nutritional content prediction, illness, and damage detection in recent years. Rodriguez, Garcia, Pardo, Chavez, and Luque-Baena (2018) utilized deep learning technology to discriminate amongst plum types (Black Splendor, OwentT, and Angelino) at early maturity stages. To create the dataset, photographs of samples of various kinds and maturities were taken. The suggested approach split the pictures first to eliminate the undesirable backdrop, and then used CNN to classify the images based on the recorded images. As a CNN model, the Alex Net architecture was selected. In various gathered datasets, the categorization accuracy varies from 91 percent to 97 percent.

- *Meat and Aquatic Product Quality Detection*: For protein provision, aquatic items (such as fish, shrimp, and so on) and meat (such as pig, mutton, beef, and so on) have become significant parts of the human diet. Multiple chemical makers may be used to monitor food safety in the aquatic manufacturing process. For fast nondestructive quality detection of aquatic goods (for example, chemical characteristics of fish muscle prediction), spectral sensing and machine intelligence have been extensively utilized in recent years Data analysis techniques such as partial least squares regression (PLSR), SVM, LR, and others may be used to estimate quality, freshness, and nutritional content of samples using spectral data [7]. Deep learning techniques have recently been brought into this field to replace conventional machine learning methods, thanks to adequate proof of excellent feature learning and data analysis capacity. A deep learning model for predicting shrimp freshness using visible/near-infrared hyperspectral data. The deep characteristics of the samples were generated using the SAE model, and logistic regression was used to identify the freshness grade of shrimp using the deep features acquired. For shrimp freshness grade categorization, the suggested approach yielded positive results (96.55 percent and 93.97 percent in calibration and prediction sets, respectively).

- *Contamination of Food*: Food may be contaminated with toxic and harmful chemicals as a result of the environment or human factors affecting food throughout any phase of planting or feeding, growth, harvesting or slaughtering, processing, storage, transportation, and sale, among others, before consumption. Food contamination may cause gastrointestinal infectious illnesses and damage to human health, and as a result, it is gaining worldwide attention. Song, Zheng, Xue, Sheng, and Zhao used DNN to develop an evolving approach for forecasting gastrointestinal infection morbidity caused by food contamination. The study was designed to predict the morbidity of gastrointestinal infectious diseases using a large amount of contaminant-related data (from 227 types of contaminants in various concentrations and 119 types of commonly consumed foods in the investigated region) collected in the previous week, as well as previously recorded morbidity data. The dataset's large data of contaminant indexes was given by food safety departments in the target area in central China, while the morbidity data was provided by gastrointestinal departments at hospitals in the corresponding studied region. To extract hidden features for contamination indices, a deep demisingauto encoder, which is a structure similar to SAE with several hidden layers, was built, and the recovered representation was utilized for supervised learning to predict morbidity. With a mean average percentage error of 21.16 percent and a success rate of 58.50 percent, the proposed ecogeography-based optimization (EBO)-based approach for the calibration of the DDAE model outperformed conventional ANN and deep demisingauto encoder trained by other methods. The authors came to the conclusion that the deep learning model has significant skills in dealing with partial and defective data. More possible contamination characteristics will need to be considered in the future [8].

- *Food categorization and recognition*: Diets and eating habits may have an impact on human health. Diabetics, allergic individuals, and others, in particular, should keep a close eye on and manage their eating habits. Food categorization and identification are essential tasks that assist humans in keeping track of their regular meals. Food images are one of the most significant sources of information on the qualities of food. Furthermore, for food appearance analysis, image sensing is a very simple and low-cost information collection method [9]. The vast differences in food form, volume, texture, color, and components make food identification a difficult job for natural goods like food and processed food. Food identification and categorization are also affected by the backdrop and arrangement of food items. Image analysis is now the most often utilized pattern in food identification and classification, because to the widespread usage of CNN.

2. DISCUSSION

Feature learning is the most important benefit of deep learning technology. Traditional machine learning methods deal with categorization problems based on hand-crafted features or utilize raw data as input. Deep learning techniques are more capable than conventional approaches in learning representational characteristics from a dataset during the training phase. Another feature of deep learning is the capacity to transmit knowledge. We discovered that the majority of the studies mentioned in the section "Food recognition and classification" used pertained CNN models based on large datasets (such as ImageNet) and fine-tuned the models on their target datasets, which could reduce the difficulty and time required to train a model (even if the dataset was much smaller). Furthermore, several authors used CNN features to train another classifier, such as SVM, in order to transfer information from the CNN model to the new classifier [10].Deep learning technology, unlike traditional data analysis techniques, requires a more sophisticated model structure and computing effort, which has previously restricted its development and use. Many tools have developed to assist researchers get a fast start making a deep learning-based APP, owing to the worldwide focus on deep learning and the contributions of scientists. It seems that programming is tough.

Complicated neural network models, but we can rapidly construct the necessary network with the assistance of these existing frameworks. Model by calling several duplicate network structures and stacking them on top of each other encapsulated function interfaces encapsulated function interfaces encapsulated function interfaces. In terms of hardware, a graphics processing unit (GPU) in conjunction with a Compute Unified Device. The NVIDIA CUDA Deep Learning Toolkit and the NVIDIA CUDA Architecture Toolkitmay offer. Deep learning computations may be accelerated using both hardware and software. These toolkits help popular deep learning frameworks run faster. as already stated Acceleration software and hardware are very useful. Reduce computation time and have the ability to fulfill deadlines real-time data processing needs. However, there is no denying that deep learning has flaws. Due to a lengthy training period and hardware limitations, Added to that, there's a lot of complexity and a lot of hyper parameters. The optimization efforts for the model would be very difficult. As well as time-consuming. GPUs for computer acceleration, as well as corresponding CPUs and other gear, are extremely costly. It will take considerably longer to train a DNN using just this method. The computing hardware is comprised of CPUs. In addition, deep learning

For training, large data is required, as is the collection of dependable big data. Another tough issue is the dataset. Data gathering and annotation will consume a significant amount of time and effort. a few public datasets for. The results of academic study and a challenge competition were gathered and analyzed. Experts or volunteers may hand-label items, or they may be directly labeled. Machines would download data from the Internet; as a result, there would be some errors are unavoidable. It should also be mentioned that the only the dataset's features can be understood by a trained network. Used as a training tool Incomplete datasets are described in certain published datasets.

3. CONCLUSION

We looked at a huge number of recent papers for this study. linked to the deep learning in food APP, detailed description of the. DNNs were used to process food picture, spectrum, text, and other data. The suggested structure, training techniques, and final evaluation result of DNNs were used to process food image, spectrum, text, and other data. Information in each of the articles examined When it comes to performance, we compared deep learning to other widely used techniques and found that in the research we looked at, the deep learning method outperformed the others. We came to a conclusion. The benefits and drawbacks of deep learning techniques a thorough examination of the issues and prospects for the future in the field of food deep learning It is, to the best of the writers' knowledge, The first study of deep learning applications in the food industry. The goal of this review is to motivate scholars and professionals in the field. This area to conduct additional food-related studies using deep learning techniques, to offer accurate answers to classification or regression issues and to put them into operation for the benefit of the food industry. Inspection of the quality and safety of food for human consumption. Finally, we've arrived.

- The use of deep learning and multisource data fusion, including RGB pictures, spectra, smell, taste, and other sensory data
- The development of full-automatic information, and so on, would be examined to create a more complete evaluation of food. Acquisition equipment/systems for food with a steady signal output. Appropriate venues for exchanging global food data should be investigated in the. future, since food-related big data is currently difficult to get by.

  As a result of the use of automated or even manual data management and sharing technologies that aren't comprehensive
- the data science potential of deep learning technologies. Food-related sectors that are seldom investigated, such as mining, may be assessed. Sensory and consumption of food, food supply chain, and so forth, and
- Successful deep learning instances, such as in the food industry (for example, in the food industry).Picture recognition, a recipe suggestion app with intelligence, andfruit quality assessment system) may be converted into products that are useful.

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