Review on Food Categorization Techniques in Machine Learning.

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ABSTRACT: *In machine learning lots of techniques are available for food categorization. Various Food categorization System are also working to provide certainty for food industry. Food categorization is essential step in food industry. Both small scale & large scale food industries requires food categorization. Manual categorization of food is very time consuming. It requires many effort for small scale industry & it is impossible for large food industry. These difficulties in categorization can be solved using machine learning techniques. This paper introduced machine learning techniques for categorization of food for efficient categorization which includes KNN, SVM, Logistic regression and CNN with advantages, limitations & performance evaluation parameters.*

Key Words: *Machine learning, KNN, SVM, logistic regression, CNN.*

I. INTRODUCTION

Food is a necessary part of human lives, now day's food is processed, transported & grown very fast. Food industry contains complex activities like categorization of food products, food supply, and food consumption. Processed products of food & partially made instant packets of food are part of today's lifestyle. A possible area of applying machine learning or deep learning technology in food industry is food handling. Machine learning do not required detailed programming. It learn from previous experiences. We just provide data to generic algorithms & hence there is no need of writing the code. It builds the logic from the data itself. Deep learning is part of machine learning where neural networks gain knowledge from huge data. Likewise we gain knowledge from experience, the algorithm of deep learning would accomplish a task again & again, each time pulling it slightly to enhance the outcome. Applying machine learning or deep learning technology in food industry not only saves the manual time required for manual categorization of food but also increases the production of items. Because different types of food products can be produced in the same food industry. The food can vary even within the same product type, so the most important step is the categorization of different food products. Various machine learning techniques for efficient food categorization includes KNN, SVM, and Logistic regression and CNN.

The general block diagram for classification of images is as shown in figure 1.

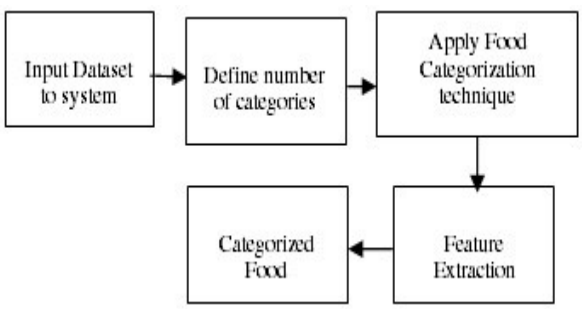

Fig. 1: The general block diagram for categorization of Food

First the food image is acquired by camera. Each camera has its own characteristics. The camera giving best performance can be selected. The image can be RGB or Grey image given to the system. Define number of categories to categorize food. Apply categorization techniques like KNN, SVM, Logistic regression and CNN. The features can be extracted automatically or by programmer. Finally categorized food is the result of the technique.

II. LITERATURE SURVEY

In [1], Seng divided the work into two parts. In the first part they presented review on viticulture technology. In the second part they collected the dataset for image classification. They also applied different classifiers like SVM, KNN, and CNN on two different dataset. In [2], Gang proposed improved KNN algorithm. They pointed out the limitation of KNN i.e. it get affected by rating in music system. In improved KNN they used previous knn along with baseline algorithm. So improved the performance of KNN after the rating.

Baseline algorithm predict the estimate of baseline for user. In [3], Dalal used two classifiers for classification of cancer of breast. First one SVM using two coding models which are LLC, BoF for feature extraction. The other one was CNN, which extract the feature automatically. In [4], Meriem classified the cancer of breast into two categories. Generally the cancer is classified into two types which are benign/malign.They presented & compared NB, KNN classifiers for efficient classification of cancer. In [6], Alberto combined different techniques of machine learning to form the ensemble methods. They used two different configurations for implementations. First using three distance & second using five distances. They showed the implementations using weights. In [7], Mrunmayi predicted the diseases that a single person might be affected with lifestyle using SVM. The industry of healthcare collects the data collects lot of data related to diseases. But this data does not aim to collect the hidden information of people which is related to the lifestyle diseases. So collecting information related to lifestyle and using SVM to predict & classify the diseases that a persons might be liable. In [8], Kai created a model based on predictions of multilayer to improve the multi-objective classification for logistic regression. Based on model structure multilayer predictions are formed. In [9], Yian categorize the different fashion items into labelled items. This helps to search the specific style item easily. They proposed the architecture of GoogLenet & fine-tuned this network for their fashion based images. Their dataset has small size so reduces the time required for training. In [10], Norbert completed the analytical study of results of matches of sport. RNN like LSTM is used for proposed solution. This architecture easily deal with the problem of gradient. Such machine learning algorithm help to predict the outcome of the succeeding match.

The rest of the part of this paper is organized as follows. Section II includes various Food categorization techniques. Section III includes performance parameters for Food categorization techniques. Section IV includes results and discussions. Section V includes conclusion.

III. VARIOUS FOOD CATEGORIZATION TECHNIQUES

Various techniques are proposed for categorization of foods. In this paper we compared 4 techniques which are KNN, SVM, Logistic Regression, and CNN. Every technique explained below has different approach. Technique can be chosen based on the requirements & application required.

A. Categorization of Food using KNN

KNN stands for K- Nearest Neighbour. The KNN algorithm is widely used in industry for classification problem. The "K" in KNN algorithm is the nearest neighbours we wish to take vote from. It is number of nearest neighbours used in the classification. K affected in the algorithm as the boundary between two classes becomes smoother with increasing value of K. With infinitely increasing value of K, finally both class gets separated depending on the total majority. Figure 2 shows class 1of food by circle & class 2 of food by triangle. Rectangle is the class of food to be identified as either class 1 or class 2.

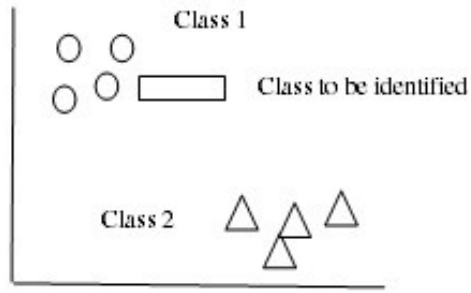

Fig. 2: KNN classification

B. Categorization of Food using SVM

SVM stands for Support Vector Machine. It is binary classifier but it can be used for multi-class classification. It can be used for classification as well as for regression. In industry, mostly it is used for classification problem. It can be used for speech recognition, image recognition, and computer vision application. SVM use an optimal hyperplane between two classes such that the margin between the two classes can be maximized. Data points close to optimal separating hyperplane are called as support vectors. Figure 3 shows the idea behind the SVM classification.

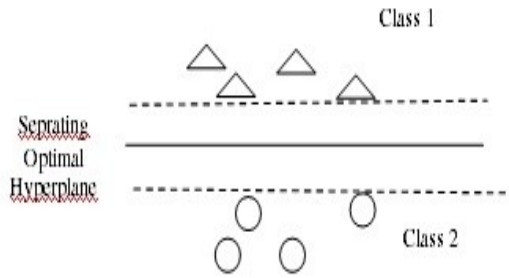

Fig. 3: SVM classification

In SVM, it is easy to have a linear hyper-plane between these two classes. SVM has a technique called the kernel trick**.** These are functions which takes low dimensional input space and transform it to a higher dimensional space i.e. it

converts not separable problem to separable problem, these functions are called kernels. It is mostly useful in non-linear separation problem.
Different kernels can be used in SVM are Gaussian, Linear, Polynomial, Sigmoid.

C. Categorization of Food using Logistic Regression

Logistic regression is a binary classifier. Using group of predictors it classify object into one of the two classes. Logistic regression convert its outcome using the function like logistic sigmoid to give back a value of probability which is represented in to two or more discrete classes. It is used for the discrete variable output. It is used for classifying winner of the election, student will fail or pass in their exam, whether a consumer will come return or not, whether the email not spam or it is spam.
Figure 4 shows the idea behind the Logistic regression classification.
Logistic regression has various application in churn problem of customer, classification of Alzheimer's disease, prediction of loan [13], [14], [15], [16].

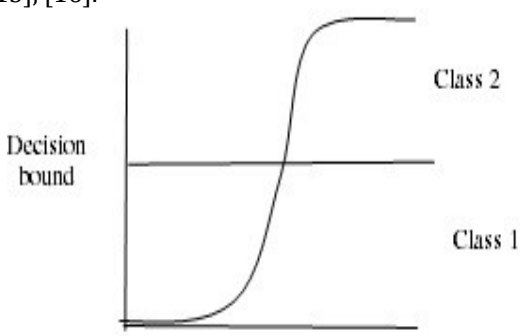

Fig. 4: Logistic regression classification

D. Categorization of Food using CNN

CNN stands for Convolution Neural Network. The big advantage of CNN is automatic feature learning. The working principle of CNN is convolution which gives feature maps which are filtered & they are stacked over one another. Traditional neural network does not perform automatic feature learning. Figure 5 shows the basic structure of CNN. It has input layer, output layer & lots of hidden layer.
Input layer holds the values of raw pixel. CONV layer calculate neurons output. The neurons are connected to local to input at local regions, each computes dot product between a small region they are connected to in the input volume & their weights.

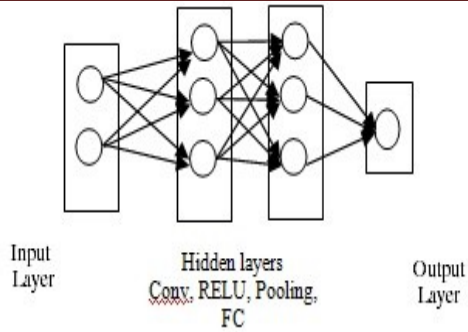

Fig. 5: Basic structure of CNN

RELU layer apply activation function element wise, for example the max (0, x) thresholding at zero. This operation leaves the size of the volume same. POOL layer perform a down sampling along the spatial dimensions (height, width), resulting in volume. FC layer compute the scores of class, resulting in volume of size, where each of the numbers belongs to a class score, such as among the categories of dataset.
CNN has various application in stereo vision, stereo matching, computer based detection & enhancement of images for underwater [19], [20], [21], [22].

IV. PERFORMANCE PARAMETERS

Confusion matrix:
Calculating accuracy, error, Sensitivity, Specificity" Precision, False positive rate etc.
It is kind of table used to represent the performance of a classifier. It looks simple, but sometimes seems to be confusing.
Following parameters can be estimated from the matrix.
Consider the classification problem: It is apple or not apple.
TP: True Positives: Predicted yes & it is the apple.
TN: True Negatives: Predicted no, & it is not the apple.
FP: False positives: Predicted yes, but actually not the apple (Called Type 1 error)
FN: False negatives: Predicted no, but actually it is the apple. (Called Type 2 error)
Accuracy: Overall, how many times the classifier correct.
Measures how correct our predictions were.
(TP+TN)/total
Misclassification Rate: Overall, how many times it is wrong.
(FP+FN)/total
True Positive Rate: It is actually yes, how many times it predict yes. Also called as "Recall" or "Sensitivity"
TP/actual yes
False Positive Rate: It is actually no, how many

times it predict yes.
FP/actual no
True Negative Rate: It is actually no, how many it predict no.
TN/actual no
Equivalent to 1-False Positive Rate and called as Specificity.

V. RESULT & DISCUSSINS

Table 1, 2 shows comparative analysis of various food categorization techniques, the techniques can be selected as per the requirements. We can see complexity of CNN is more than other classifiers like KNN, SVM, and Logistic regression. But CNN has highest accuracy. But the dataset required for CNN is very huge than other classifiers. The big advantage of CNN than other classifier is automatic feature learning. Other classifiers do not have automatic feature learning. CNN has highest accuracy than other classifiers. But the speed of learning CNN is more than other classifiers.
From below comparative analysis of various food categorization techniques, the techniques can be selected as per the requirements.

Table 1: Comparison of Food categorization techniques

Technique	**Categorization of food using KNN**	**Categorization of food using SVM**
Input	Image	Image
Complexity	Less complex	Less complex
Speed of learning	**less**	Moderate
Dataset requirement	Moderate	Moderate
Feature extraction mode	Decided by programmer	Decided by programmer
Applications	Recommender System Herta security Concept search	Cancer classification Text categorization
Accuracy	Less than SVM & more than logistic regression	More than KNN & less than CNN

Table 2: Comparison of Food categorization techniques

Technique	**Categorization of food using Logistic regression**	**Categorization of food using CNN**
Input	Image	Image
Complexity	Moderate	More complex
Speed of learning	More	**More**
Dataset requirement	Moderate	**Large**
Feature selection mode	Decided by programmer	**Automatic by algorithm**
Applications	Analysis of diagnostic data	**Traffic sign detection Image retrieval Image classification**
Accuracy	Less than KNN & CNN	**Highest than all others**

Fig. 6 shows analysis of the Accuracy for various image classification techniques.
From the analysis of accuracy, logistic regression has less accuracy & CNN has highest accuracy.

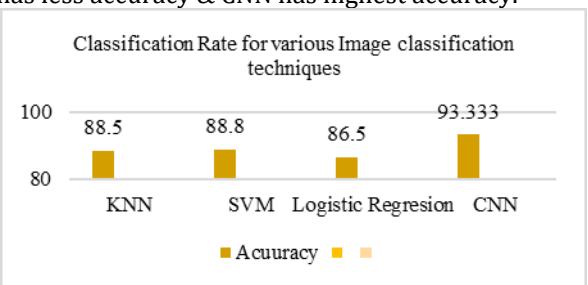

Fig. 6: Analysis of the Accuracy for various Image classification techniques
(Data [1], [11])

VI. CONCLUSION

In this paper various techniques for the categorization of food are represented. The requirement of food categorization & the current state of art techniques are represented. The comparison of the various techniques for food categorization is performed. This comparison includes input image type, amount of dataset requirement, feature extraction, speed of learning, complexity of method, applications & performance parameters are presented. The main advantage of CNN automatic feature learning while the other techniques do not have this advantage. But the dataset requirement for CNN than other technique is huge.

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