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Multi label restaurant classification using support vector machine

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ABSTRACT

Many internet websites are hosted with a vast amount of information about restaurants which are not identified properly according to some predefined features to fit users' interests. Thus, restaurant classification was needed to solve this problem. Restaurant classification has become very important for individuals and food business applications to spread their services via the Internet. In this paper, a modest model is proposed to classify restaurants based on their predefined features which are used as factors affecting restaurant's ratings. The usage of multi label classification is utilized for labelling to maintain acceptable requirements for restaurant's services. Two proposed labels are suggested resulted from the output of two classifiers each operate on a specific set of features. Support vector machine is used for classification because of its effectiveness in restaurant's label separation. The final prediction label is yielded after applying the proposed hypothesis rules. The experimental results conducting Zomato dataset show that the proposed multi label model achieved approximately about 88% for prediction accuracy. Using the proposed model for classification had led to get a collection of accepted restaurants according to user favorites.

Keywords: Classification, Multi Label, Resturants, Support Vector Machine, Zomato data Set.

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1. Introduction

Food applications in the world of today are getting more common due to their functions to display reserve and order food with simple interactions on the mobile phone to the favorite restaurant, by observing other user ratings of previously visited customers [1]. The basic task of these applications is providing a associated suggestions to customers by using their preferences to forecast ratings by utilizing the beliefs of customers to help exploring effectively new things of interest from a possibly countless set of varieties [2-4]. An example of multi-label learning is automatic classification of restaurant attributes. The users can label the businesses with some attributes such as if it is suitable for children or if it is healthy or not [5-7]. Restaurants classification uses data mining to make decisions, predicts future customer demands and predicts database records in pre-defined categories based on certain criteria. The common tools for classification are logistic regression, Naive Bayes, and SVM [8, 9]. This paper is concentrated and contributed on restaurant multi label classification approach to classify restaurants into predefined labels based on their features using support vector machine.
The main contributions of this paper are:

1. Multi labelling approach is utilized instead of multi class approach. The proposed model is built using a classifier for each suggested label to classify restaurants efficiently based on their predefined feature sets extracted from the available data.
2. Classification is performed using support vector machine with Gaussian kernel function to yield an accurate separation of class label.
3. The proposed hypothesis (rules) is suggested to predict the label for each tested restaurant.

The rest of this paper is organized as follows: In the next section, the highlighted related work is presented thoughtfully while in section 3, the classification method definitions are summed up. Section 4 explained the proposed model that is created to classify the restaurants into two predefined classes. A discussion regarding

the results gained from the proposed model took place in section 5, and finally in section 6, there were conclusions.

2. Related work

In what follows, some of the previous researches that are related to the techniques that used Support Vector Machine (SVM) with employing different data sets and Multi-label classification are listed below.
This paper[10], suggested a Classifier Chain (CC) model for classification based on binary relevance method. A novel chaining approach was suggested to model the correlations of labels. It was shown that resultant Classifier Chain model (CC) do better than other state-of-the-art methods in terms of accuracy and macro-averaged F-measure. This paper[5], suggest five models that training an SVM classifier and other classification methods, by using Yelp business photos founding that the two simple models which utilized transfer learning and gradient boosting classifiers the highest performance. This paper [11], designed an automated approach to decide the approximated revenue for new restaurant by using Support Vector Machines with Gaussian kernel, Naive Bayes and Random Forest on certain parameters. The resulted output values indicated that the annual revenue of the proposed restaurant site was about (5017319 $) dollars. This paper [12], emphases on predicting the rating and popularity change of restaurants by utilizing machine learning methods such as logistic regression, Neural Network, Naïve Bayes and Support Vector Machine (SVM) to make related predictions. Yelp data set was used for experiments. It was shown that logistic regression had the best performance. This paper[13], presented a model to predict the healthiness of restaurants based on ranking between 90-100 and conducting Yelp data set. Support Vector Machine with linear kernel was used for classification and SelectKBest was utilized for feature selection. It was shown that SVM was the best in sensitivity performance compared with other methods. This paper [14], suggested restaurants based on user behavior and restaurant ranking using Zomato's API. Restaurants are recommended to users by considering their location, interests and restaurant's arrangements. An android and web application is proposed to generate suggestions based on restaurant popularity for users. This paper [15], proposed a model to examine a number of features about restaurants located in different areas of the city and analyzed them to predict the restaurant's rating. Zomato data set was considered for experiments to analyses restaurant's factors for improving customer satisfaction levels. This paper[16], suggested a model to understand the factors that affect the ranking of restaurants by using Zomato dataset and presented 8 regression algorithms based on the results of regression techniques. It was shown that random forest regression had the highest performance in terms of regression degree and lowest error rate. Table 1 depicts the previous studies including the methodology used, on what data set is performed and their gaps. From these studies, it was identified that multi labelling classification using support vector machine is not considered and it was proposed to develop the solution to the research problem.

Table 1. The related works and their methodologies, data set and gaps

ref No	Year	Aim of paper	Methodology	Paper proposal	Dataset	Gaps
8	2009	suggested a Classifier	Classifier Chain model (CC)	novel chaining approach	Multi label datasets	Multi-class classification using binary methods
5	2016	training an SVM classifier	Convolutional Neural Networks	Utilized two simple models	Yelp	Multi-class classification training an SVM classifier with
9	2016	decide the approxim ate	Support Vector Machines ,Gaussian	prediction system for future revenues	kaggle	Multi-class classification depending on revenue only
10	2017	predicting the rating and popularity change of	logistic regression, Neural Network, Naive Bayes and Support	linear regression logistic regression perform better than the Native	Yelp	Multi-class classification. Don’t have enough feature resulting low accuracy.

ref No	Year	Aim of paper	Methodology	Paper proposal	Dataset	Gaps
11	2018	predict the healthines s of	Support Vector Machine, linear kernel	Prediction model	Yelp	Using Multi-class classification by utilizing linear SVM
12	2018	suggested restaurant s on user behavior	Recommendatio n system	Design a Recommended Module by restaurant	Zomato	Multi-class classification based on location and user behavior features only.
13	2019	predict the rating to help	SVM, Linear Decis,regression ion Tree,	Ada Boost Regression gives the highest	Zomato	Multi-class classification. SVM resulting is 43%
14	2020	suggested a model to understan	8 regression algorithms	Random Forest Regression has the best	Zomato	Multi-class classification.

2.1. Classification methods

Machine learning is known as one of the major branches of artificial intelligence. It uses information theory of the mathematical models for getting results [17]. The major classes of machine learning algorithms are:
1. Supervised Learning: is applied on training dataset that takes the form of input variables with previously known outputs. The mapping function is learnt by the algorithm from the input to the output. Classification methods are abstract-learning machines that try to make a correct prediction based on what has been learned from the training data set [18-20].
2. Unsupervised learning: is applied when data is available only in the form of an entry and there is no output variable. An example is clustering [21-23]. The multi-class classification which is the traditional single-label classification, associates an example x with a single label S from a predefined set of labels SL. In contrast, the multi-label classification approach associates a subset of labels "S ⊆ L" with each example. Transformation is an approach used in multi-label problem. It transforms the data set into one or more single-label problems, then transforms back into multi-label. The process is done by training a classifier (which is independent binary) for each label and then predicting the complete label set by combining the individual labels. In addition, it takes into consideration the gathering among multiple labels in any specified order which leads to a good performance [24]. Transformation approaches employed algorithms such as Support Vector Machines, Naive Bayes and k Nearest Neighbor [16, 25, 26]. Support Vector Machine (SVM) was introduced by Vapnik (1999) and is widely used in a variety of applications [19]. It aims to find one or more hyper-planes that separate the classes of labeled-data points [27, 28]. It is an abstract supervised machine learning algorithm that learns from a dataset and attempts to generalize and make a correct classification on new datasets by classifying data into two given categories. SVM uses a separating hyper-plane to provide a decision boundary with margin to each category of data as large as possible [29, 30]. After the hyper-plane is placed, it separates the data in training set that is either classified incorrectly or correctly but very close to the hyper-plane [31, 32]. There are two methods in SVM, they are: (One-Against-All) which creates a binary classifier for every class that helps to separate the objects in the same class and (One-Against-One) which is the resultant of classifying object on two class classifiers [33-36].

3. The proposed predictive model

In this section, the stages of the proposed multi label model are presented. The main purpose of this paper is to classify the target restaurants based on their features to discover useful decisions for restaurant business. Multi label classification using SVM is the fundamental operation in the proposed model. In this work, Zomato data set is utilized for testing our proposed model where this model transforms the specified features in Zomato data set into two single-label problem, then transforms it again into multi-label classification using two classifiers. The process is done by training the two classifiers (which are independent binary) for each label and then predicting the final label combination by combining the individual predicted labels to produce the decision label

for a resturant. This work comprises three steps: Data set preparation, data preprocessing and building the proposed multi label model based on predictive modeling. The following are the main stages of the proposed model and the block diagram in Figure. 1 shows the main stages.

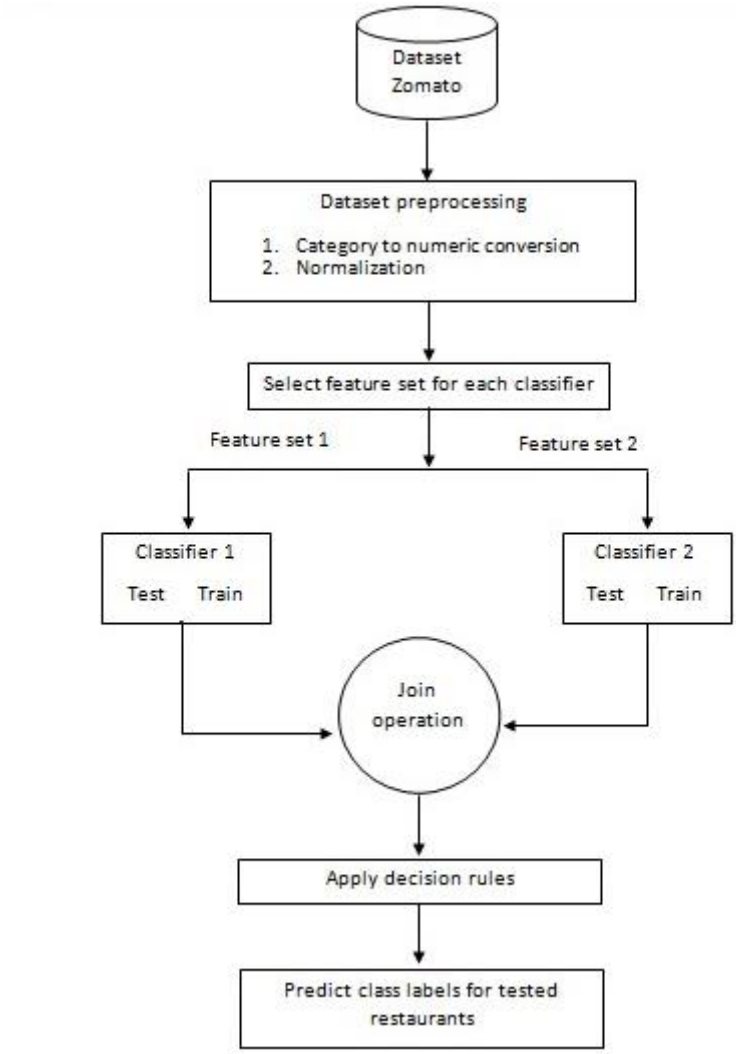

Figure 1. The Proposed Multi Label Model

A-**Data Preparation Stage:** Data collection is an essential step in building the proposed model. Zomato data set is selected for investigation because it has enormous number of restaurants for data analysis to deduce interesting predictions. The data is downloaded from kaggle website as a CSV file and converted to matrix form for processing.

B-**The Preprocessing Stage:** In this stage, the Zomato data set contains restaurant's features that need to be transformed into a suitable form for the next stage[37]. These features are of varied data types and need to be converted to a suitable form in order to improve the performance of the proposed model after applying SVM algorithm. This stage involves the following steps:

1. Dropping the unnecessary features in the data set that have no effect in deciding the rating of the restaurants such as Restaurant Name, Country Code, City, Address, Locality, Locality Verbose, Longitude and Latitude.
2. Applying encoding label to convert the categorical features into numerical values in order to be convenient input for the proposed classifier 1. The features **"Has Table booking, Has Online delivery, is delivering now, Switch to order menu"** from Zomato data set are chosen to be transformed. The encoding label encodes the Yes and No values to 1 and 0 respectively.
3. The values in **"aggregate rating"** feature of Zomato data set, which is considered a respond variable, are rounded to their nearest integer. The resultant aggregate rating multinomial values became from 1 to 5.

4. The "Average Cost for two" feature is converted into US $ formatting because it has different standard currency values.
5. Normalization method is applied on the numeric features as there are different scale ranges. Normalization will bring all the values to a common range to be input for the proposed classifier 2. The features are "Cuisines, Average Cost for two, Price range and Votes". A Min-Max normalization method is utilized as shown in Eq. (1):

$$x_{normalized} = \frac{x - x_{min}}{x_{min} - x_{max}} \quad \ldots (1)$$

Each feature value is considered as x. the x_{min} and x_{max} are the smallest and largest values in the feature column respectively. After preprocessing operations, the proposed multi label prediction model is built according to the transformed features.

C- **Building the Proposed Multi Label Model.** After preprocessing step, the proposed multi label model is made up of of building two classifiers. Each classifier is trained and tested with specific features of Zomato data set. Then the output label of each classifier is checked by applying the proposed decision rules to predict the restaurant labels.

Table 2 depicts the proposed classifiers, their feature sets and the new created proposed labels.

Table 2. The proposed classifiers and their feature sets

Proposed Classifiers	Classification method	Number of features	Feature Set	Respond Label	Decision Label
Classifier 1	SVM	4 out of 8	• Has table booking • Has Online delivery • is delivering now • switch to order menu	Aggregate Rating	Has pleasant Delivery Service
Classifier 2	SVM	4 out of 8	• Cuisines • Average cost for two • Price range •vote	Aggregate Rating	Is Classy Ambiance

As shown in Table 2, Four out of eight significant features of Zomato data set are selected for each classifier to enable higher performance in classification. Building the proposed classifiers is shown in the following steps:

1. The first proposed classifier1 is built utilizing the nonlinear support vector machine SVM method on four encoded features of Zomato dataset. The feature set is: **"Has Table booking, Has Online delivery, Is delivering now** and **Switch to order menu".** A new label named "**Has pleasant delivery service**" is created as new column vector in the new matrix which is the result of implementing classifier1 to classify the restaurants into 1 to 5 sub labels (sub categories) according to the respond variable "aggregate rating". It was observed from the data set that when **Has Online delivery** and **Is delivering now** features are ones the rating value is higher.

2. The second proposed classifier 2 implemented nonlinear support vector machine SVM method on the other four normalized features of Zomato dataset. The feature set is: **"Cuisines, Average Cost for two, Price range** and **Votes"**. A new label named "**Is classy ambiance** "is created as new column vector which is the result of implementing classifier2 to classify the restaurants into 1 to 5 sub labels (sub categories) according

to the respond variable “aggregate rating”. It is observed from the data set that the classy ambiance of a restaurant plays an essential role in raising the rating values.

3. As a final step, the output of each proposed classifiers (classifier1 & classifier2) are joined with union operator according to the following proposed assumptions to produce the final label:

If classifier 1(output label) >=3 and classifier2(output label) >=3 then

Restaurant has pleasant delivery service and is classy ambiance.

If classifier 1(output label) >=3 and classifier2(output label) < 3 then

Restaurant has pleasant delivery service but not classy ambiance.

If classifier 1(output label) < 3 and classifier2(output label) >=3 then

Restaurant not has pleasant delivery service but is classy ambiance.

If classifier 1(output label) <3 and classifier 2(output label) <3 then

Restaurant not has pleasant delivery service and not classy ambiance.

Figure 2 shows an example of prediction output after implementing the proposed assumptions on the output of the two classifiers. It is shown that when the output of classifier 1 (delivery service label) rating was 2 and the output of classifier 2 (classy ambiance label) was 4, the multi label classification decision for the tested restaurant will be classy ambiance because classifier2 predicted 4 for classy ambiance which is greater than the threshold value 3. Figure 3 depicts a snapshot of some classified restaurants after implementing the proposed model.

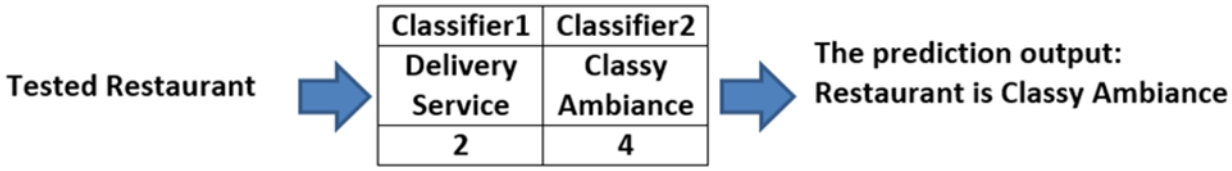

Figure 2. The proposed Multi label model implementation.

Restaurant ID	Restaurant Name	Country Code	cuisines	Average cost for two	Has Table booking	Has Online delivery	Is delivering now	Switch to order menu	Price range	VOTE/MAX VOTE	label Aggregate rating	classifer 1	classfier 2	outpout label
6317637	Le Petit Souffle	162	0.3	0.3	1	0	0	0	0.7	0.029	5	1	4	Is classy ambiance
6304287	Izakaya Kikufuji	162	0.0	0.3	1	0	0	0	0.7	0.054	5	1	3	Is classy ambiance
6300002	it - Eds a Shangr	162	0.5	0.8	1	0	0	0	1.0	0.025	4	1	4	Is classy ambiance
6318506	Ooma	162	0.2	0.3	1	1	1	0	1.0	0.033	5	4	2	Has pleasant delivery service
6314302	Sambo Kojin	162	0.2	0.3	1	0	0	0	1.0	0.021	1	1	2	not good service
18189371	Din Tai Fung	162	0.0	0.0	1	0	0	0	0.7	0.031	3	2	2	not good service
6300781	Buffet 101	162	0.2	0.3	1	0	1	1	1.0	0.048	3	3	2	Has pleasant delivery service
6301290	Vikings	162	0.5	0.3	1	1	1	1	1.0	0.062	4	5	3	Has pleasant delivery service and Is classy ambiance
6300010	ftel Philippine Pl	162	0.3	1.0	1	0	0	0	1.0	0.057	1	1	1	not good service
6314987	Locavore	162	0.0	0.3	1	0	0	0	0.7	0.049	2	1	3	Is classy ambiance
6309903	Silantro Fil-Mex	162	0.2	0.0	0	0	0	1	0.7	0.098	5	1	3	Is classy ambiance
6309455	's Creamery & C	162	0.3	0.0	1	1	1	0	0.7	0.045	3	3	3	Has pleasant delivery service and Is classy ambiance
6318433	Silantro Fil-Mex	162	0.2	0.7	1	1	1	0	0.7	0.027	5	3	5	Has pleasant delivery service and Is classy ambiance
6310470	Guevarra's	162	0.0	0.0	1	0	0	0	0.7	0.042	4	4	2	Has pleasant delivery service

Figure 3. A snapshot of the output of classifier 1, classifier 2 and final decision label

4. Results and discussion

In this section, the performance of the two classifiers detecting the labels (Has pleasant delivery service and is classy ambiance) and the proposed multi label model is presented. In our experiments, we have implemented our work using MATLAB on Zomato dataset. **Zomato Data Set.** It is downloaded from Kaggle data repository. It consists of 19 features and 9543 rows from numerous restaurants. The attributes presented in the dataset are: "Restaurant Id, Restaurant Name, Country Code, City, Address, Locality, Locality Verbose, Latitude, Cuisines,

Average Cost for two, Has Table booking, Has Online delivery, Is delivering, Switch to order menu, Price range, Aggregate Rating, Rating color, Rating text, Votes".

4.1. **Experimental results**

In this section, the experimental results are presented and shown as figures after applying the proposed multi label model. Restaurant features are extracted first and preprocessed to be ready for classification using SVM method with linear and Gaussian kernel functions. For each classifier, the data set is split into 80% Training set (about 6673 restaurants) and 20% testing set (about 1906 restaurants). The two classifiers are implemented in parallel pool to save time. Figure 4 below specifies the number of observations for classifier1 using the designated features. Table 3 depicts classifier1 training with different SVM model types. The respond variable "aggregate rating" has 5 classes. After experimental work on classifier 1, it was shown that the accuracy and training time are varied slightly through different SVM models. It was shown that using linear SVM had minimum training time amongst the others. Also, it was observed that applying SVM with PCA reduction method using variance 95% lead to minimize the training time which was about 6.6 sec.

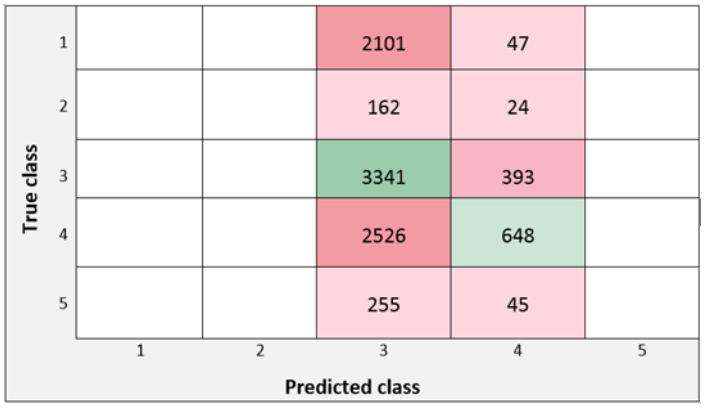

Figure 4. The Number of Observation for Classifier 1

Table 3. Classifier 1 Evaluation Performance

SVM Model	Kernel function	Accuracy	Training Time Sec	True positive Rate	False Negative Rate
Linear SVM	linear	80.5%	15.8	89%	11%
Fine Gaussian SVM	Gaussian	80.5%	20.4	89%	11%
Medium Gaussian SVM	Gaussian	80.5%	24.8	89%	11%
Coarse Gaussian SVM	Gaussian	80.5%	30.7	89%	11%

observations for classifier2 using the designated features.

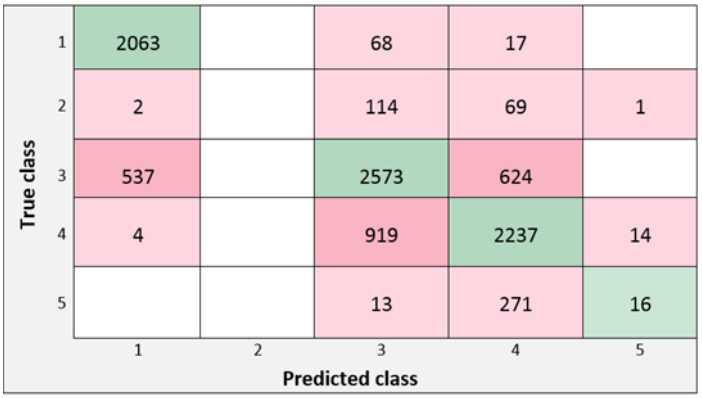

Figure 5. The Number of Observation for Classifier 2

Table 4 depicts different values for accuracy depending on the model type. PCA with variance 95% did not get good results when applied on classifier 2 and spent longer time in execution. So its result is discarded.

Table 4. Classifier 2 Performance Evaluation

SVM Model		Kernel Function	Accuracy	Training Time sec	True Positive Rate	False Negative
Fine	Gaussian	Gaussian	90%	35	96%	4%
Medium	Gaussian	Gaussian	87%	57.5	91%	9%
Coarse	Gaussian	Gaussian	80.5%	79	75%	25%

After applying the performance measurements on the proposed classifiers, a testing phase is implemented to evaluate the prediction output of the proposed multi label model i.e. evaluating the two class labels (has pleasant delivery service and is classy ambiance) at the same time. The final accuracy is measured as shown in Eq.2 below:

$$accuarcy = \frac{number\ of\ correct\ prediction}{total\ number\ of\ predictions} \qquad (2)$$

The accuracy value was about 88%. Figure. 6 show the performance of the proposed multi label model. The area under the Roc curve is about 0.87 which is a good indication for the model performance.

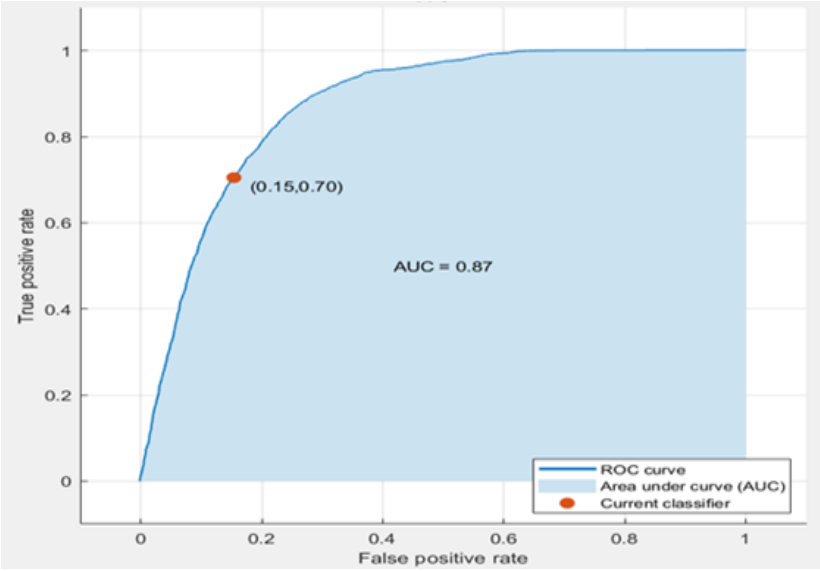

Figure 6. The Roc curve of the proposed multi label model

5. Conclusion

In this paper, an improvement in restaurant classification is gained by building multi label model which consist of two classifiers. Each single label classifier has different input features to yield proposed class label suited to customer requirement. SVM provided a good decision boundary between classes on Zomato dataset and operated well on the categorical features. The features chosen for each classifier found to be significant and influential in predicting results. Thus, the selected restaurant's features in Zomato data set are proved to be good factors affecting the restaurant revenue as customers will be influenced by the ratings to dine in their favorite restaurant. In addition, this work can be generalized to process other data sets to produce a decision. After implementation, many restaurants are classified to have pleasant delivery service which is considered a good decision for customer satisfaction during the pandemic. Some of redundant features are removed as these have no effect on the dependent labels and would lead to decreased accuracy.

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