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A SEMINAR REPORT
ON

PRODUCT RECOMMENDATION SYSTEM

SUBMITTED BY

Ameya Abhay Chavan
Roll No. 31115
Class TE-1

Under the guidance of
Prof. P. S. Vidap

DEPARTMENT OF COMPUTER ENGINEERING
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CERTIFICATE

This is to certify that the Seminar report entitled

"IMAGE BASED PRODUCT RECOMMENDATION SYSTEM"

Submitted by

Ameya Abhay Chavan Roll No. 31115

has satisfactorily completed a seminar report under the guidance of Prof. P. S. Vidap towards the partial fulfillment of third year Computer Engineering Semester II, Academic Year 2019-20 of Savitribai Phule Pune University.

Prof. Prof. P. S. Vidap
Internal Guide

Prof. M.S.Takalikar
Head
Department of Computer Engineering

Place:
Date:

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Abstract

As more and more business are getting connected through the Internet, a lot of similar products are available for sale, and hence the need for better search results. Most of the existing e-commerce websites are largely dependent on keyword matching and user history as their searching mechanism.

A convenient and reliable way of searching, is image based searching. It is an efficient and interactive way for querying related products, since product description displays a broad range of variation from supplier's side to receiver's side. The user will provide an image, and similar image based products will be presented to the user.

Some machine learning model is used to classify the input image as one of the product categories. Then another neural network is used to calculate the similarity using methods like Jaccard similarity, cosine similarity, etc., which is used to select the closest product from dataset. Overall process is discussed to demonstrate the efficacy of image based search for product recommendation in practical applications.

Keywords

Random Forest, SVM, JPEG Compression, KNN, Cosine Similarity.

1 INTRODUCTION

The e-commerce world is fast evolving and is certainly growing around the world. Global retail sales growth will continue to rise have increased their retail market share. For instance, according to eMarketer, e-commerce sales might achieve $6.39 trillion, taking up 21.8% of total retail sales. Even though all kinds of business had a tough time in 2020, national markets which are covered by eMarketer presented tremendous e-commerce growth. For example, Latin America had a huge growth (36.7%), even after considering a 3.4% drop in overall business. The e-commerce sector of Argentina saw a growth of 79% in 2020, which is followed by Singapore, at 71.1%.

However, the enormous amount of gathered digital information has lead to the challenge of information overload for online customers, which hinders their timely access to interested products on the Internet. Thus increasing the need for recommendation systems. Today's e-commerce companies use their own recommendation systems, which are generally text-based and rely on data gathered from search terms, purchase history, product category, items in cart information and many more. This necessitates the buyer to give product descriptions, which differs largely from the supplier's end to receiver's end.

An alternate approach to this problem can be given through the rapidly developing technology of neural networks, which can help shift the search paradigm from textual description to visual entry. A product snapshot will provide a detailed set of information including its brand, usage, appearance, etc. The application of artificial intelligence for image recognition is less widely used and remains considerably unexplored. Hence, a smart recommendation system is studied which requires image of objects as input rather than a textual entry as input.

In an image based search, an algorithm uses an image of the required object as input. A machine learning model then studies and classifies the object into the category it might belong to. Further, the features extracted from the last layer are fed to similarity calculation model to find the closest product from the dataset. Precisely, the functionalities studied here which are achieved in the recommendation system are:

1. Classification: The objective here is to correctly identify the product category from a random image.

2. Recommendation: The objective here is to find the most similar product from given features and category of product from the dataset.

2 MOTIVATION

Search engines have always relied on text data to categorise and give appropriate search results. The scenario has however changed since the introduction of image search by Google Images. Instead of simply analyzing text, users can be provided with ways to search by content.

Since computer vision AI is evolving and machines have begun to see and understand more, visual search implementation is growing widely. With introduction of visual search, a change in user's search habits have been noticed. Thus e-commerce websites need to make use of it since visual search is a gateway to new possibilities in cases where the buyer lacks clarity about how to describe a certain product, but a visual reference.

Thus machine learning in the back-end studies the product image dataset learning through features like shapes, colors, brands, and returns visually similar results according to user's requirement.

3 LITERATURE SURVEY

3.1 Image-Based Service Recommendation System: A JPEG-Coefficient RFs Approach [1]

In this paper, on the basis of user interaction, an idea to search the products efficiently in an e-commerce system using image based searching techniques is proposed. The paper consists of two important parts, Part 1 and Part 2. The proposed recommendation system learns the category/class/type of the product in Part 1. For Part 2, it retrieves similar products matched with input image.

The system uses Machine Learning(ML) to study the image/product features and generates a learned model. Further this model is used to categorize the queried product. Further in Part 2, from a particular class of products, the Euclidian distance based on JPEG feature vectors is used to get the 20 most similar product images. Top 10 most relevant products are then retrieved from the proposed Structural-Histogram approach, which uses the image features.

In the ML phase(Part 1) where the product category is learned, the authors have employed a Random Forests (RF) meta-classifier because of its excellent performance and generalization capability. The JPEG coefficients are used for feature extraction.

The paper uses Amazon dataset containing 20 categories of products for its proof of concepts. For enhancing performance of the proposed recommendation system, the RF model is further integrated into a Deep Learning setup.

3.2 Image-based Product Recommendation System with Convolutional Neural Networks [2]

The authors in this paper focus on two major problems which they want to solve. Firstly, determining the category of the given image; and secondly, recommend the most closely matching product according to the given image. This paper is majorly Convolutional Neural Networks based.

To solve the classification problem which is the given input image is to be classified into one of the 20 categories, the paper proposes construction of deep convolutional networks like AlexNet and VGG model which are compared with a baseline Support Vector Machine model.

For feature vectors of images, the last fully connected layer in the classification model is used to solve the recommendation problem. There is one feature vector mapped to any images in the dataset, which is fed as input to the recommendation system. The steps included in this are feature extraction, similarity calculation with comparison between cosine similarity method and Jaccard similarity method and output(recommendation).

The paper uses Amazon dataset of product image including data from between May 1996 to July 2014, which has 9.4 million products, out of which 3.5 million products are useful since others lack images.

3.3 Image Based Fashion Product Recommendation with Deep Learning [3]

In this paper, the fashion products are recommended to the customer by automatically extracting the available information of the user. A Deep Learning framework is created which helps recommend products/ images of similar style and taste. This approach is tested by using a publicly available fashion dataset. The framework is divided into two stages.

In the first stage, a Convolutional Neural Network (CNN) is trained for solving tasks related to image classification. This neural network classifier is used as an image feature extractor which also behaves as an input for recommendations. Here, Convolutional Neural Networks are trained separately for the prediction of the category of the product and texture type.

In the second stage, the k-nearest algorithm (k-NN) is used for ranking in feature space. After the first stage, the remaining Convolutional Neural Networks are integrated and used to extract the feature vector. The k-NN is then used to search the closest relevant item to the feature space.

The paper proposes a method that requires a single input to receive a list of similar style recommendations. The framework used helps in increasing the performance by accurately matching to the customer's style.

3.4 Image Based Search Engine Using Deep Learning [4]

The paper proposes an architecture of Deep Learning for CBIR systems. They have applied Convolutional Neural Networks for studying feature representation from the data containing images. A pre-trained CNN model, that is, Inception-v3 model, a GoogleNet deep architecture is applied on the dataset. The trained CNN is then used to classify objects according to their classes and perform an analysis to return the most relevantly similar image to that of an input image.

CBIR indexes pictures by extracting the visible features such a shape and colour. These indexed features are responsible for the retrieval of images. The information of pictures is separated by multi-dimensional vector features which in turn forms a feature database. An input image should be provided by the user to fetch a similar image. This input image is modified by the image retrieval model into a representative model of feature vectors. The image is retrieved by studying input image and the vectors of pictures in the database.

The semantic gap between the image pixels and the semantics perceived by humans is solved by Deep Learning. CNNs are used to handle image data which is a two-dimensional grid of pixels. The property of CNN to be able to learn shapes, colours and textures makes it suitable for applying it in the image-based search system. The paper depicts a way to model a reliable image retrieval system that will manage a database of images in a precise manner.

4 PROBLEM DEFINITION AND SCOPE

4.1 Problem Definition

To design a system to extract the meaningful product features from large dataset to increase the efficiency of image matching.

4.2 Scope

Classification of the product into right category and image feature extraction from dataset is most important task, as similarity scoring depends on this. As if similarity scoring is wrong it could have adverse effects on the output of the whole system.

The results of image-based search have wide applications ranging from search engine optimization to product recommendation in e-commerce.

5 DIFFERENT MACHINE LEARNING ALGORITHM

5.1 Support Vector Machine (SVM)

It is a Supervised Learning algorithm which is used for Classification and Regression. Although, it is primarily used for Classification problems in Machine Learning.

Here the objective in SVM algorithm is to generate a best line or decision boundary which can sort out n-dimensional space into classes so that new data can be easily put into the correct category in future. The best decision boundary hence created is called the hyperplane.In SVM, extreme points/vectors are choosed for creating the hyperplane. Since the extreme cases are called as support vectors, the algorithm is called as Support Vector Machine.

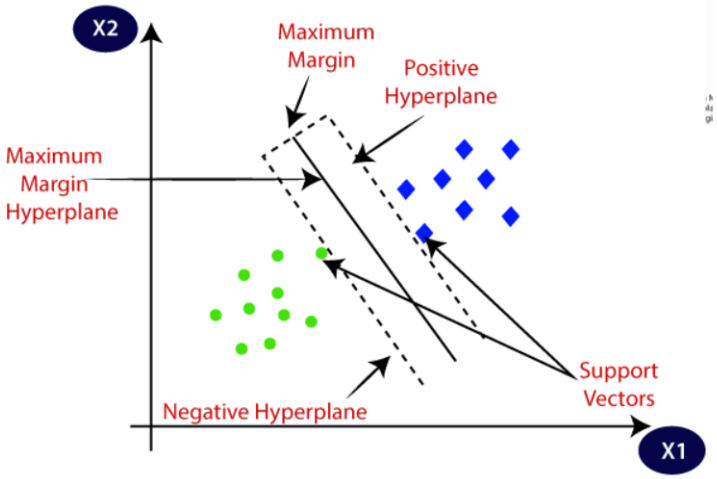

Figure 1: SVM Vectors

5.2 Random Forest Algorithm

It is a Supervised Learning algorithm that is used for Classification and Regression problems in Machine Learning. It combines multiple classifiers for complex problem and improve the performance of the model, which is based on the concept of ensemble learning.

Random Forest contains a number number of decision trees based on different subsets of a given dataset and then takes their average to improvise the accuracy which is to be predicted for the dataset. It predicts the final output based on the majority prediction votes from different decision trees. Clearly, more number of decision trees in the forest will generate higher accuracy results.

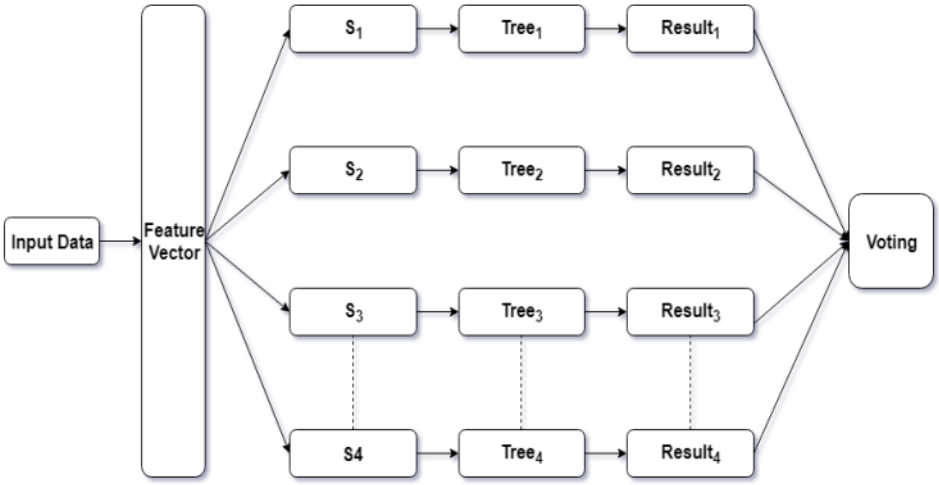

Figure 2: Random Forest Classifier[1]

5.3 JPEG Coefficient Algorithm

JPEG (Joint Photographic Experts Group) Coefficient algorithm converts RGB color format to YCbCr format[1]. There are high frequency colors which are sensitive to human eye. Cb and Cr which are colors of chromium compounds are less sensitive to human eyes, are ignored. Thus the image can be divided into 8*8 pixel and Direct Cosine Transformation can be performed. The image is thus converted into binary form(0, 1) and compressed by applying any encoding like Huffman encoding.

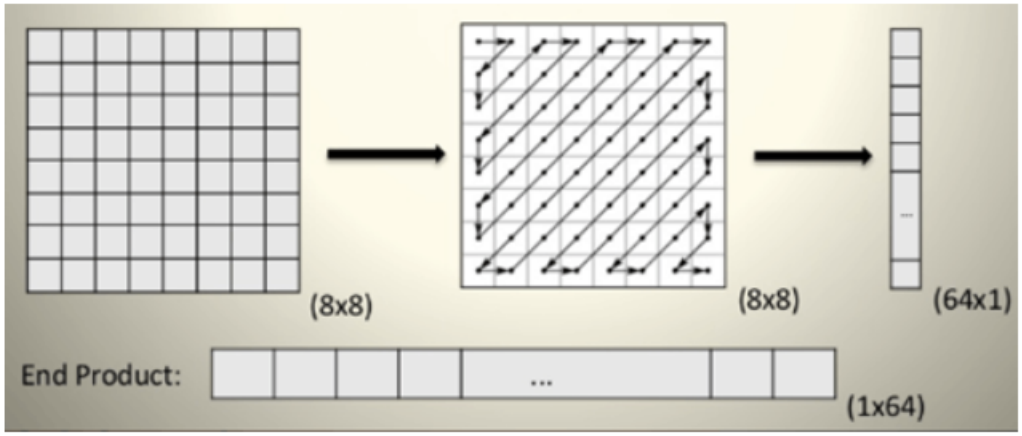

Figure 3: JPEG Compression

6 ALGORITHM

The recommended system[1] uses a two phase, Phase 1 and Phase 2, algorithm to perform an image-based search to find products closest to the one selected by the user.

6.1 Phase 1:

1. Phase 1 of the algorithm is employed to learn the class/category of the product by relying on the image characteristics.
2. This phase is based on the testing and training of a machine learning model. This machine learning process for learning the class of product is done with the help of random forest classifier.
3. To train the machine learning model, features are extracted on the basis of JPEG coefficients.
4. This is done by converting the JPEG coefficients into feature vectors, which acts as the feature vector for the random forest classifier.
5. The random forest classifier further learns the feature distribution across various categories of products. The random forest classifier is further integrated with a Deep Learning model which is comprised of 5 Convolution Layers.
6. The resulting model is stored to find find the product category which maps to the query image.

6.2 Phase 2:

1. Phase 2 of the algorithm is responsible for recommending the closely matched image to the query product image.
2. Next, the similarity is calculated between the feature vector of the category images and the queried product image. For this purpose, Euclidean distance is calculated between all the vectors of the products in selected category to the vectors of input image.
3. The best possible choices are presented as the top 20 elements from the sorted list arranged in ascending order of the similarity values achieved in the previous step.
4. The top 20 candidates are re-loaded for color matching of items. This is done by introducing color histogram and is called the "Struct-Hist" matching process.
5. The "Struct-Hist" has an scaled outcome between 0 and 1 where 0 means no match, and 1 means complete match. The two approaches(Euclidean distance and Struct-Hist) are hence combined to recommend 10 most relevant images for the image-based search.

7 METHODOLOGY

7.1 Workflow

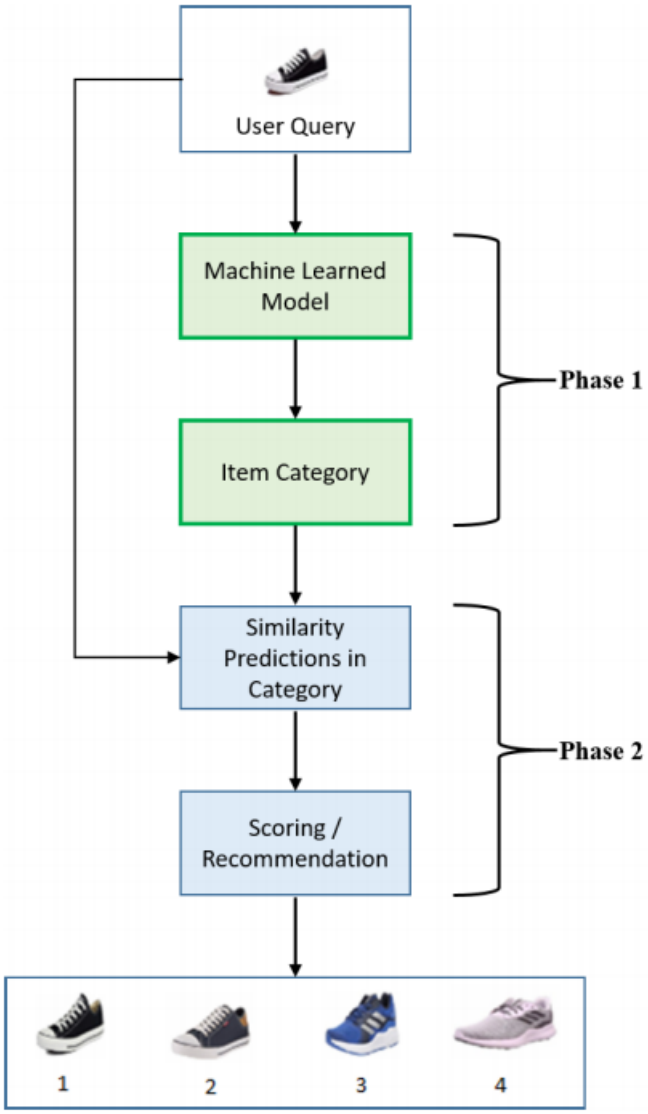

Figure 4: The generic flow of the proposed recommendation approach. Green represents "Phase 1" which learns the category of the query image. The blue color represents the "Phase 2" which retrieves similar images from a particular category of images.

Phase 1: Category learning (Green color)
Phase 2: Recommendation (Blue color)

7.2 Mathematical model

Euclidian Distance

$$Euc\_Dist = \sqrt{\sum_{i=1}^{n}(q_i - p_i)^2}$$

p, q: vectors
Let p, q be two vectors
The Euclidian Distance is then used as the similarity score
where the output is scaled between 0 and 1.

Cosine Similarity

$$Cos\_Sim = \frac{A \cdot B}{||A||\ ||B||} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}}$$

A_i, B_i : image vector components

The Cosine Similarity is also used as the similarity score
where the output is scaled between 0 and 1.

Output

In both the models results are obtained in the range 0 to 1, where 0 indicates 0% similarity and 1 indicates 100% similarity.

8 Results

8.1 Prediction accuracy for datasets used in different references.

Table 1: Data Table

S.No	Data set	Accuracy
1	Amazon	84%
2	Amazon	50%
3	Fashion Dataset	87%
4	Yahoo! v1	98.78%

8.2 Parameters and time complexity for algorithm discussed[1]

Parameters	Avg. Time (Seconds)
Time for calculating and learning the JPEG features by RF	**35**
Time to find the category of the query image by the JPEG and RF	**0.03**
Time for calculating and learning the Deep features by RF	**1000**
Time to find the category of the query image by the Deep features and RF	**0.3**
Time to find the top 20 related items from the dataset	**1**
Time to retrieve the 10 related items out of 20 already retrieved	**0.003**

Figure 5: Parameters and time complexity[1]

In phase 1[1] of the algorithm discussed the Random Forest gives a precision of 74.9%, which is further enhanced to 85% by integrating it with Deep Learning model.

The Euclidean distance gives score of 0.98 for the Struct-Hist method and the Cosine similarity score for the same is 0.965, which more when compared to other methods such as KNN(0.96 with euclidean similarity) and search based(0.95 with euclidean similarity), hence it is selected[1].

9 CONCLUSION

A two phase recommendation model is built, which performs classification and recommendation in respective phases. Machine learning models are used for classification purposes and similarity scoring is done using algorithms like Euclidean Distance and Cosine Similarity for recommendation phase. Further in some cases the machine learning model is integrated into Deep learning setup for enhanced results. A recommendation model thus generates results with decent accuracy of around 80% taking 0.3 seconds for classification phase and 0.03 seconds for retrieving phase when the experiments are conducted on Core i7, running the Titan Nvidia GPU. In future the Recurrent Neural Network architecture can be used to merge non-visual data with visual data for recommendation process.

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