Cloth Pattern Recognition & Retrieval System

Submitted in partial fulfillment of the requirements

of the degree of

Bachelor of Engineering

by

Jayesh Kukreja	**41**
Pritesh Satpute	**65**
Ankit Vishwakarma	**79**

Supervisor:

Prof. Udaychandra Nayak

UNIVERSITY OF MUMBAI

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2016-2017

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CERTIFICATE

This is to certify that the project entitled **"Cloth Pattern Recognition & Retrieval System"** is a bonafide work of

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submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of **Undergraduate** in **Bachelor of Information Technology**

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Project Report Approval for B.E.

This project report entitled **"Cloth Pattern Recognition & Retrieval System"** by **Jayesh Kukreja, Pritesh Satpute, Ankit Vishwakarma** is approved for the degree of **Bachelor of Engineering in Information Technology**

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Declaration

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Abstract

The aim of our project is to design a system where user can find similar clothes online based on input image to the system.

The image is captured by the camera and get processed to identify features like pattern, colour, collar type ,text and sleeve type of the respective image using DL models . After identifying the features the generated query is then given to Bing API. Cloth recognition algorithms are often confronted with 3 fundamental challenges when adopted in real world applications i.e. Clothes often have large variations in styles, textures and patterns; clothing items are frequently subject to deformations and occlusions; clothing images often exhibit serious variations .Thus, through our project we try to develop the above aforementioned system while considering the challenges.

Keywords: Computer Vision, Artificial Intelligence, Deep Learning

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Chapter 1

Introduction

1.1 Problem Statement

To provide an efficient algorithm that is both effective and economical in performing cloth pattern detection task and retrieval from web without compromising on lighting, wrinkles or orientational parameters.

1.2 Scope of the Project

Ease the work of the user for finding clothes online based on an input image. We've created dataset which consists of around 300 images per feature category. Classes are as follow:

- Pattern Type: Plaid, Striped, Solid, Irregular
- Sleeve Type: Sleeveless, Half Sleeve, full sleeve
- Collar Type: Crewneck, Polo Neck, V-Neck

1.3 Need for the Proposed System

- Minimize user browsing time:
  When it comes to online shopping, users are browsing more and buying less. Shoppers look across various sites for clothes. According to data

from the survey, two-thirds of consumers on average (66%) say they have specific product in mind and look for just that.

- Increase conversion rate [Probability of user browsing and buying]:
  Allowing user to find and locate clothes alternative across various sites, thereby increasing conversion rate.

- Improving the search experience and its efficiency:
  Online shoppers can upload an image to the site, or take a picture in an app, to look for similar products in the Retailer's catalog in a blink of an eye. This paves the way for much better product discovery experience, as shoppers don't need to wander through endless sub-categories to find that leopard print furry coat – especially that in many cases they may not even know how it's called what they are looking for.

- Find less expensive, similar pieces of clothing:
  At some point in our lives, we all have fallen in love with an item, but found it too expensive to buy. With visual search solutions running in the app or website, Retailers can suggest similar-looking items in different price ranges, so the customer can buy a look-alike product at a lower price. This feature can become a staple in e-commerce sites, as it can be used to offer relevant recommendations, based on items the shopper looked at but didn't buy. Of course, Retailers can also use such solutions to upsell to the customer, showing higher value alternatives that look alike.

- Increased product discovery accuracy.

- Marketers will be able to gain better insights into customer motivations and, more importantly, habits to provide a more tailored experience.

- Brands are also tapping into visual search to give customers a gentle nudge to continue shopping when they are tempted to navigate away from the eCommerce website.

1.4 Summary of the results and task completed

After a thorough research and analysis, our main agenda was to develop a system which will be able to predict feature labels and various attributes mentioned above and generate a query to obtain data online.
This also led to the process of data collection for different features. This data

was obtained from Google Image and Bing Images.
We decided to target only t-shirts, since all the necessary data is either not available or not accessible to us, we self generated dataset based on our study.
During the initial phase of our project we used a custom 14 Layer Convolution neural network for feature prediction but later realised using a Pre-trained model can better suit our problem due to low quality and quantity of our datasets. Hence, we shifted to Inception v3. The accuracy of that model after transfer learning was 80%+ across all classes, which was 15-20% increase from our previous model with the exception of one.

Chapter 2

Review of Literature

2.1 Summary of the investigation in the published papers

Cloth Pattern Recognition with Four Features

Automatic clothing pattern recognition is a challenging research problem due to rotation, scaling, illumination, and especially large intra-class pattern variations. This paper recognizes clothing patterns in four categories (plaid, striped, pattern-less, and irregular) and identifies clothing colors. To recognize clothing patterns, we propose a novel Radon Transform Descriptor (RTD), Scale Invariant Feature Transform (SIFT), Mathematical Morphology (MM) based global feature and a schema to extract Statistical Descriptor (STA) to capture global features of clothing patterns. They all are combined to recognize complex clothing patterns. Our approach achieves 96% recognition accuracy which significantly outperforms the state-of-the-art texture analysis methods on clothing pattern recognition.

Cloth Pattern Recognition for Visually Impaired People

Visually impaired people face several challenges in their day to day lives such a picking up clothes of their interest, Our system will help them assist in this task and works in an effort to encourage their individuality without any human supervision. Matching clothes is a challenging task for many blind people,

The use of an efficient computer vision-based system to match clothes with multiple colours and complex patterns helps assist visually impaired and blind people by distinguishing both pattern and colour information. The three main components in our methodology for clothes matching: Colour detection and matching, Pattern detection, Pattern matching. The test feature extraction from the image is comprising of RADON signature curve, DWT pattern and SIFT results. The resulting output shows whether the cloths are of matching colour or patters or both.

2.2 Comparison between the tools / methods / algorithms

Pattern recognition aims to classify data (patterns) based on either a priori knowledge or on statistical information extracted from the patterns. The patterns to be classified are usually groups of measurements or observations, defining points in an appropriate multidimensional space. During the last few years the researchers have proposed many mathematical approaches to solve the pattern recognition problems. Recognition strategies heavily depend on the nature of the data to be recognized. The available methods of pattern recognition may be categorized into two basic principles:

- Statistical Methods:
  Consisting the sub disciplines like discriminate analysis, feature extraction, error estimation, cluster analysis.
  Neural Networks based Methods Statistical Methods of Pattern Recognition:
  This is an approach to machine intelligence which is based on statistical modelling of data. In a statistical model, one applies probability theory and decision theory to get an algorithm. The three major issues encountered in the design of a statistical pattern recognition system are sensing, feature extraction, and classification. The primary issue is the representation of the input data which can be measured from the objects to be recognized and it is called sensing problem.
  The number of features of the pattern samples is usually very large. The features of the pattern samples are reduced by considering their salient characteristics. This process is referred to as feature extraction. The last issue of the statistical pattern recognition is the pattern classification or development of the classifier. The pattern classifier is defined as a device or

a process that sorts the given data into identifiable categories and classes. Trainable classifier is one that can improve its performance in response to the information it receives as a function of time. Training is a process by which the parameters of the classifiers are adjusted. The classifier is trained using the reduced pattern samples. It is often assumed that the pattern samples of a given class occupy a finite region in a pattern space and it is called a class region.

On comparing statistical and neural pattern recognition techniques we realize that how neural techniques are much far better than statistical techniques.

- Neural Network Based Methods:

  The pattern recognition approaches discussed so far are based on direct computation through machines. The neural approach applies biological concepts to machines for pattern recognition. The outcome of this effort is invention of artificial neural networks. Neural networks can be viewed as massively parallel computing systems consisting of an extremely large number of simple processors with many interconnections. Neural network models attempt to use some organizational principles (such as learning, generalization, adaptively, fault tolerance, distributed representation, and computation) in a network of weighted directed graphs in which the nodes are artificial neurons and directed edges (with weights) are connections between neuron outputs and neuron inputs.

  The main characteristics of neural networks are that they have the ability to learn complex nonlinear input-output relationships, use sequential training procedures, and adapt themselves to the data.

  The increasing popularity of neural network models to solve pattern recognition problems has been primarily due to their seemingly low dependence on domain-specific knowledge (relative to model-based and rule-based approaches) and due to the availability of efficient learning algorithms. Neural networks provide a new suite of nonlinear algorithms for feature extraction (using hidden layers) and classification (e.g., multilayer perceptron's). In addition, existing feature extraction and classification algorithms can also be mapped on neural network architectures for efficient (hardware) implementation.

The second type of approach focuses on content-based image retrieval (CBIR), where images are automatically indexed and retrieved with low level content

features like colour, shape and texture. In image classification and retrieval, images are represented using low level features. Because an image is an unstructured array of pixels, the first step in semantic understanding is to extract efficient and effective visual features from these pixels. Appropriate feature representation significantly improves the performance of the semantic learning techniques. Image segmentation is usually the first step to extract region-based image representation. The segmentation algorithm divides images into different components based on feature homogeneity. A number of segmentation approaches exist in the literature, such as grid based, clustering based, contour based, model based, graph based, and region growing based method. Image segmentation plays an important role in the screening of medical imaging. In the last decades, fuzzy segmentation methods, especially the fuzzy c-means algorithm, have been widely used in the image segmentation and such a success chiefly attributes to the introduction of fuzziness for the belongingness of each image pixel .This allows for the ability to make the clustering methods able to retain more information from the original image than the crisp or hard segmentation methods.

Chapter 3

Analysis and Design

3.1 Methodology / Procedure adopted

The development methodology used is Agile Methodology. We conduct meetings every 2 days in a week. Topics told in the previous meeting are studied and implemented and then discussed in the meeting. After the given task is done, new tasks are divided among the team to study and implemented. The progress of the work is written in the project booklet.

Figure 3.1: Agile Methodology.

3.2 Analysis

The whole process was divided into various small milestones. Collection of data for different feature which assist in attributes prediction was our topmost priority in the initial stages. Training various models on small samples to finalize a model. Accuracy of algorithm at each level is noted and model is further fine-tuned. Model is trained on complete dataset and integrated with rest of the pipeline.

3.2.1 Software / System Requirement Specification

- User Interface:
  Our project consists of a web portal which consist allows user to provide an image or capture using device camera. This image is send to the backend which then returns all the returns similar cloths with similarity index to the user.
- Software Stack:
  HTML / CSS, JavaScript, Python, TensorFlow, Keras, Bing API, Flask, OpenCV.

3.3 System Architecture / Design

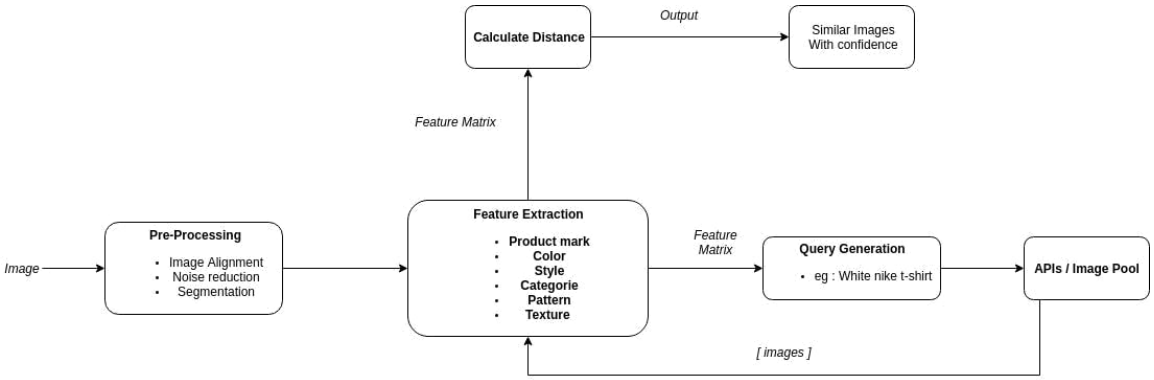

Figure 3.2: System Design.

3.3.1 Modules and their description

The Overall System Architecture can be divided into following steps:

- Pre-processing the image for any noise.

- Extracting various features from the image such as pattern, sleeve type, collar type, colour of the T-shirt and Text on the T-shirt.
- Using the features list for formulating a Query.
- Retrieving the results using the query.
- Finding Similarity index between result images and input image.

1. Pre-processing the image for any noise:
   The aim of digital image processing is to improve the image data (features) by suppressing unwanted distortions and/or enhancement of some important image features so that our AI-Computer Vision models can benefit from this improved data to work on.
   A. Resize Image:
   Images captured by a camera and fed to our algorithms vary in size, therefore, we establish a base size of 250 x 250 DPI for all images fed into our algorithms.
   B. Remove noise (Denoise):
   Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. Gaussian smoothing is also used as a pre-processing stage in if size of input image is greater than 3MB.

2. Extracting various features from the image such as pattern, sleeve type, collar type, colour of the T-shirt and Text on the T-shirt:
   We are using an ensemble approach for extracting various features. Ensemble methods is a machine learning technique that combines several base models in order to produce one optimal predictive model. Since we are only focused on T-shirts the various features used are:
   Colour, Pattern, Sleeve type, Collar type, Text

   (a) CNN Model:
   A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm which can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image and be able to differentiate one from the other. The pre-processing required in a ConvNet is much lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, ConvNets have the ability to learn these filters/characteristics.

A ConvNet is able to successfully capture the Spatial and Temporal dependencies in an image through the application of relevant filters. The architecture performs a better fitting to the image dataset due to the reduction in the number of parameters involved and reusability of weights. In other words, the network can be trained to understand the sophistication of the image better.

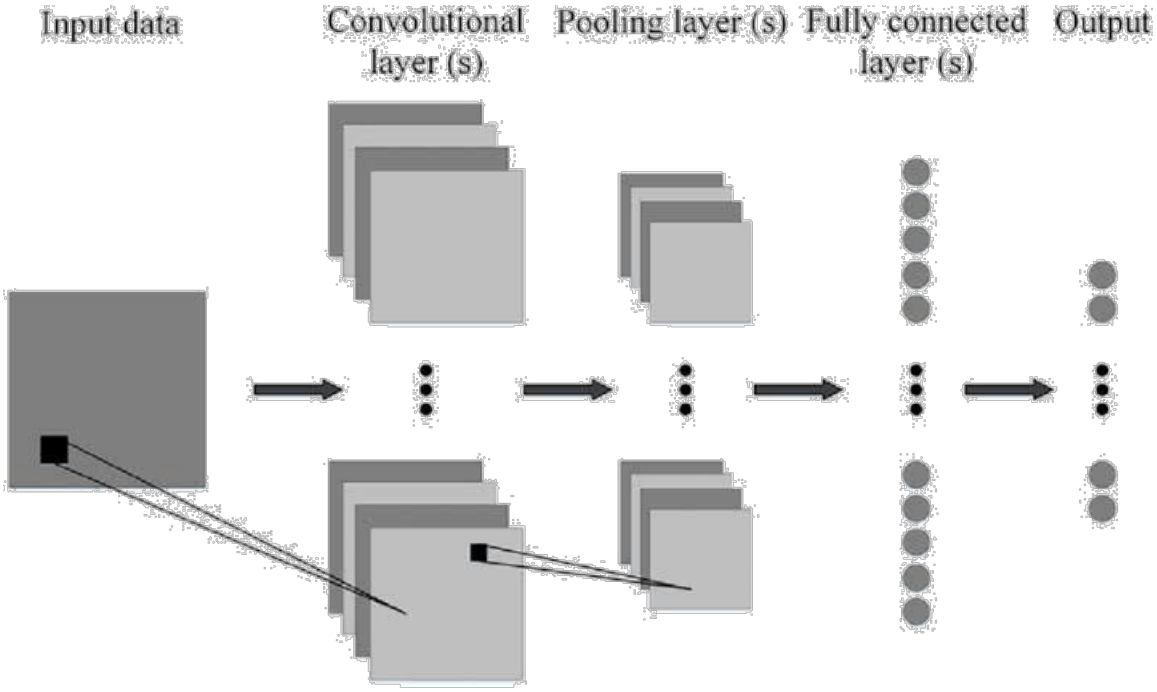

Figure 3.3: CNN Architecture.

(b) Inception Model:

Transfer learning (TL) is a research problem in machine learning (ML) that focuses on storing knowledge gained while solving one problem and applying it to a different but related problem. From the practical standpoint, reusing or transferring information from previously learned tasks for the learning of new tasks has the potential to significantly improve the sample efficiency of a reinforcement learning agent.

Inception is a widely-used image recognition model. The model itself is made up of symmetric and asymmetric building blocks, including convolutions, average pooling, max pooling, concats, dropouts, and fully connected layers. Batchnorm is used extensively throughout the model and applied to activation inputs. Loss is computed via Softmax. A high-level diagram of the model is shown below:

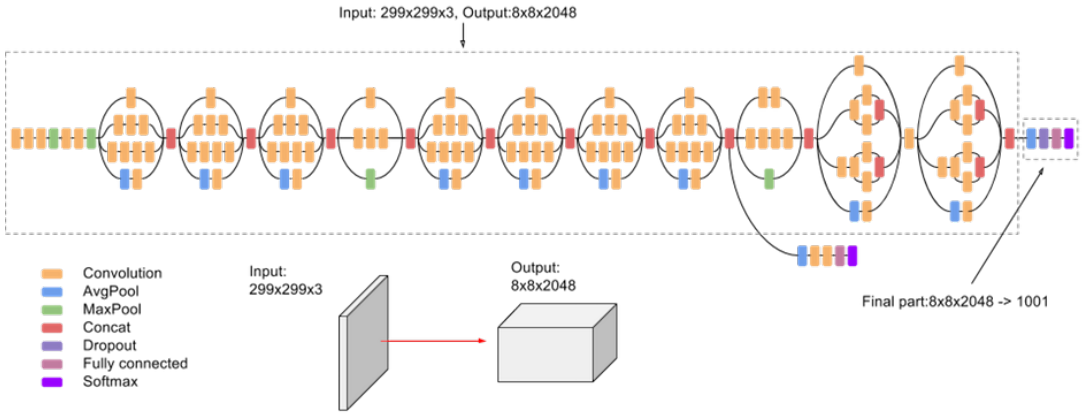

Figure 3.4: Inception Model.

(c) Custom CNN Model:

This model is only used for pattern dataset as it yielded more accuracy compared to inception. The summary of the model is given below: -

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 254, 254, 32)	896
max_pooling2d_1 (MaxPooling2	(None, 127, 127, 32)	0
conv2d_2 (Conv2D)	(None, 125, 125, 64)	18496
max_pooling2d_2 (MaxPooling2	(None, 62, 62, 64)	0
conv2d_3 (Conv2D)	(None, 60, 60, 128)	73856
max_pooling2d_3 (MaxPooling2	(None, 30, 30, 128)	0
conv2d_4 (Conv2D)	(None, 28, 28, 256)	295168
max_pooling2d_4 (MaxPooling2	(None, 14, 14, 256)	0
conv2d_5 (Conv2D)	(None, 12, 12, 512)	1180160
max_pooling2d_5 (MaxPooling2	(None, 6, 6, 512)	0
flatten_1 (Flatten)	(None, 18432)	0
dense_1 (Dense)	(None, 512)	9437696
dense_2 (Dense)	(None, 256)	131328
dense_3 (Dense)	(None, 4)	1028

Figure 3.5: Custom CNN Model.

Total params: 11,138,628

Trainable params: 11,138,628

Non-trainable params: 0

(d) Identifying Color:

i. Finding Dominant Colors:
We are using K-means to find three most dominant colors in the image. K-means algorithm is an iterative algorithm that tries to partition the dataset into K pre-defined distinct non-overlapping subgroups (clusters) where each data point belongs to only one group. It tries to make the inter-cluster data points as similar as possible while also keeping the clusters as different (far) as possible.

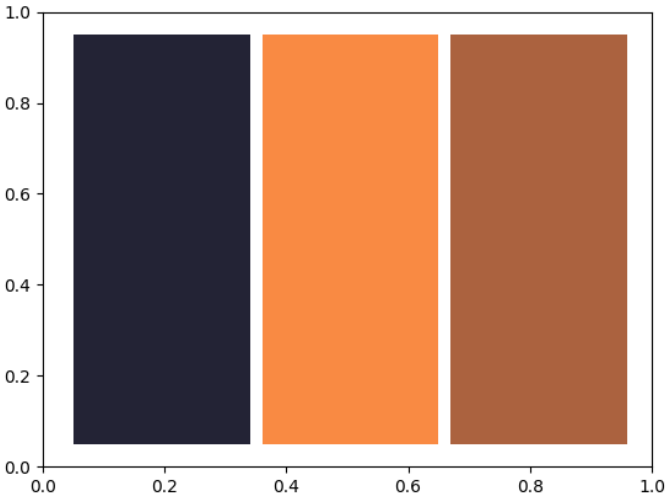

Figure 3.6: Dominant Colours.

ii. Finding Colour Names:
It assigns names to a dominant color such that the sum of the squared distance between the RGB value of the reference color names and the dominat color (euclidean distance) is at the minimum.

$$d(p,q) = sqrt[(q1-p1)^2 + (q2-p2)^2 + ... + (qn-pn)^2]^2$$

iii. Locating Text in Image:
We are using OpenCV's EAST text detector. Which is a deep learning model, based on a novel architecture and training pattern. The text sections in the image are located and then cropped before feeding to OCR for obtaining text.

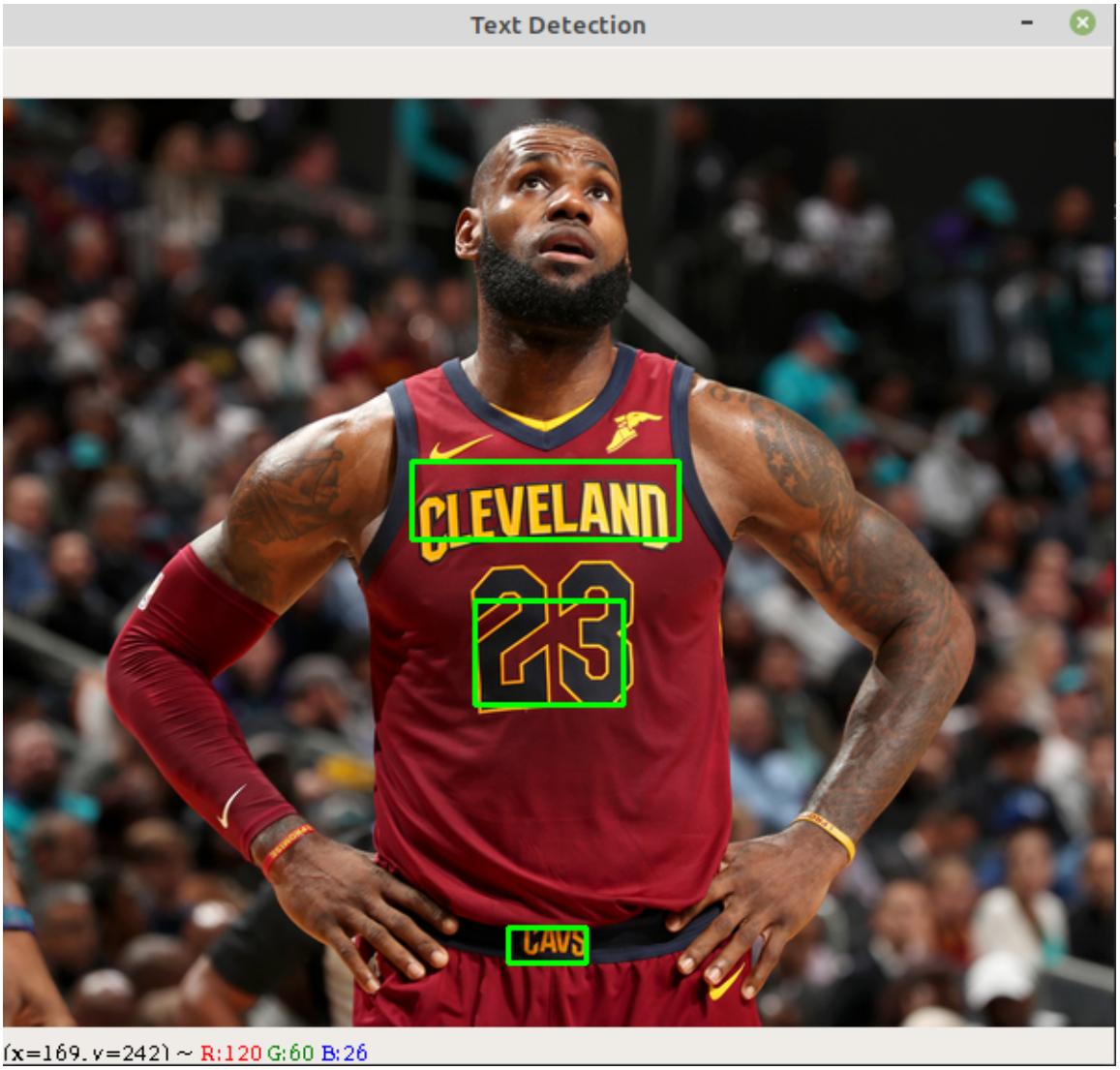

Figure 3.7: Locating Text.

iv. OCR:
We are using Tesseract engine to perform Optical character recognition. It works by finding templates in pixels, letters, words and sentences. It uses two-step approach that calls adaptive recognition. It requires one data stage for character recognition, then the second stage to fulfil any letters, it wasn't insured in, by letters that can match the word or sentence context.

v. Using Bing OCR Engine:
We are also using Bing OCR as tesseract performs poorly under noisy backgrounds and changing fonts and colours. Combining output of two OCR further improves the overall accuracy of identifying text.

3. Using the features list for formulating a Query:
   The query is formed based on the output of the above algorithms. Flow diagram of query generation

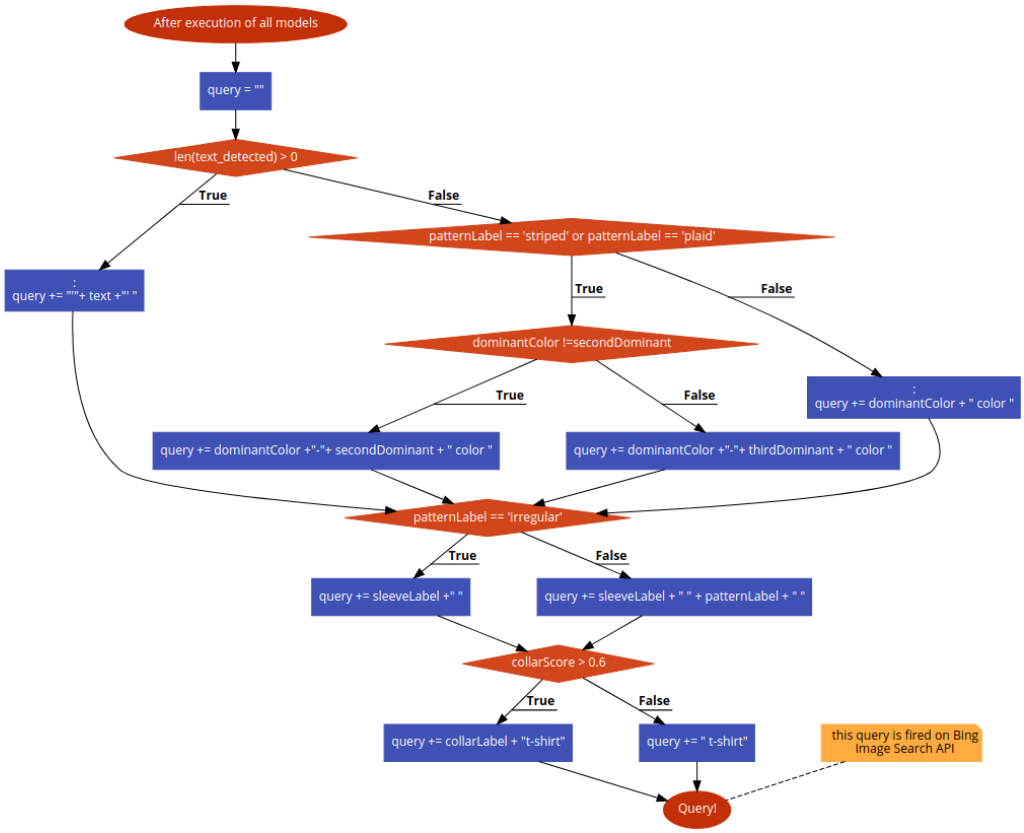

Figure 3.8: Query Formulation.

4. Retrieving the results using the query:
   The query will be given to bing api which will return response to that query.

5. Finding Similarity index between result images and input image:
   Top 10 Images obtained from Bing API are downloaded and then compared with the users input image to find the similarity between the two. For which we have used SIFT algorithm. The scale-invariant feature transform (SIFT) is an algorithm used to detect and describe local features in digital images. It locates certain key points and then furnishes them with quantitative information (so-called descriptors) which can for example be used for object recognition. A key point is the position where the feature has been detected, while the descriptor is an array containing numbers to

describe that feature. When the descriptors are similar, it means that also the feature is similar.

3.4 Software/Hardware Minimum Requirements

It is advised the website browser is updated (max 2 versions old). More older browsers might have an issue in loading some webpage functionalities. Device should have minimum 4GB of RAM and Dedicated Graphics card. Lesser RAM may lead to system lag causing undue delays.

Chapter 4

Implementation

4.1 Implementation Plan

Figure 4.1: Implementation Plan.

4.2 Coding Standard

1. Code Layout

   (a) Indentation

   - Use 4 spaces per indentation level

   (b) Maximum Line Length

   - Limit all lines to a maximum of 79 characters.

   (c) Blank Lines

- Surround top-level function and class definitions with two blank lines.
- Method definitions inside a class are surrounded by a single blank line.
- Extra blank lines may be used (sparingly) to separate groups of related functions. Blank lines may be omitted between a bunch of related one-liners.
- Use blank lines in functions, sparingly, to indicate logical sections.

(d) Source File Encoding

- All source files are encoded using UTF-8.

(e) Imports
Imports should be grouped in the following order:

- Standard library imports.
- Related third party imports.
- Local application/library specific imports.

You should put a blank line between each group of imports.

2. Naming Convention

(a) Function and Variable Names
C-style naming separates words in a name using underscores: this_is_an_identifer.

(b) Constants
Constants are usually defined on a module level and written in all capital letters with underscores separating words. Example include PATH.

4.3 Testing

- Unit Testing:
In computer programming, unit testing is a software testing method by which individual units of source code, sets of one or more computer program modules together with associated control data, usage procedures, and operating procedures, are tested to determine whether they are fit for use. For example, in our case, we have three different CNN models each trained on different feature dataset. Each of these were individually tested.

- Integration Testing:
  Sometimes called integration and testing, (abbreviated I and T) is the phase in software testing in which individual software modules are combined tested as a group. Integration testing is conducted to evaluate the compliance of a system or component with specified functional requirements. It occurs after unit testing and before validation testing. Integration testing takes as its input modules that have been unit tested, groups them in larger aggregates, applies tests defined in an integration test plan to those aggregates, and delivers as its output the integrated system ready for system testing.
  In our system, after unit testing now we have all models individually tested and all these are integrated into our system's backend. Similarly, with our website too, each button and input field is individually tested. Finally, after both, the backend and the Web App (which are the modules that are unit tested), are then integrated and tested. One of the test examples is, we test run multiple images from different client devices and browsers to ensure the system performs consistently.

- White Box Testing:
  White Box Testing (also known as Clear Box Testing, Open Box Testing, Glass Box Testing, Transparent Box Testing, Code-Based Testing or Structural Testing) is a software testing method in which the internal structure/design/implementation of the item being tested is known to the tester. Tested by group members who have full knowledge for redundancies and structural format.

4.3.1 Test Cases

From all the dataset 10% of the images are used for testing of the models.

Model Name	Classes	Image per Class	Accuracy
Sleeve Type	Half Sleeve	109 % 10 = 10	85
	Full Sleeve	116 % 10 = 11	86
	Sleeveless	239 % 10 = 23	91
		Total Images: 41	Total Accuracy: 87.3

Table 4.1: Test Case for Sleeve

Collar Type			
	Polo Neck	71%10 = 7	87
	V Neck	75%10 = 7	83
	Crew Neck	92%10 = 9	77
		Total Images: 23	Total Accuracy: 82

Table 4.2: Test Case for Collar

Pattern Type			
	Plaid	158%10 = 15	81
	Striped	159%10 = 15	88
	Irregular	157510 = 15	95
	Patternless	157%10 = 15	91
		Total Images: 60	Total Accuracy: 88.75

Table 4.3: Test Case for Pattern

Chapter 5

Results and Discussion

In order to retrieve similar clothes online, we have built a prediction system that predicts the various attributes from input cloth image and forms a query based on parameters like colour, pattern, sleeve type etc. The average accuracy of all the models is 86.11%. The individual accuracy of the models is 87.3% for sleeve model, 82% for collar model and 88.75% for pattern model. The overall success rate of the system in formulating the query based on a random sample of 20 images is 60%. The search results obtained after formulation of a query from Bing image search API are uncertain and dubious. The similarity index helps to eliminate the problem to some extent but its computationally very expensive and time consuming hence its impossible to check every image from the search result.

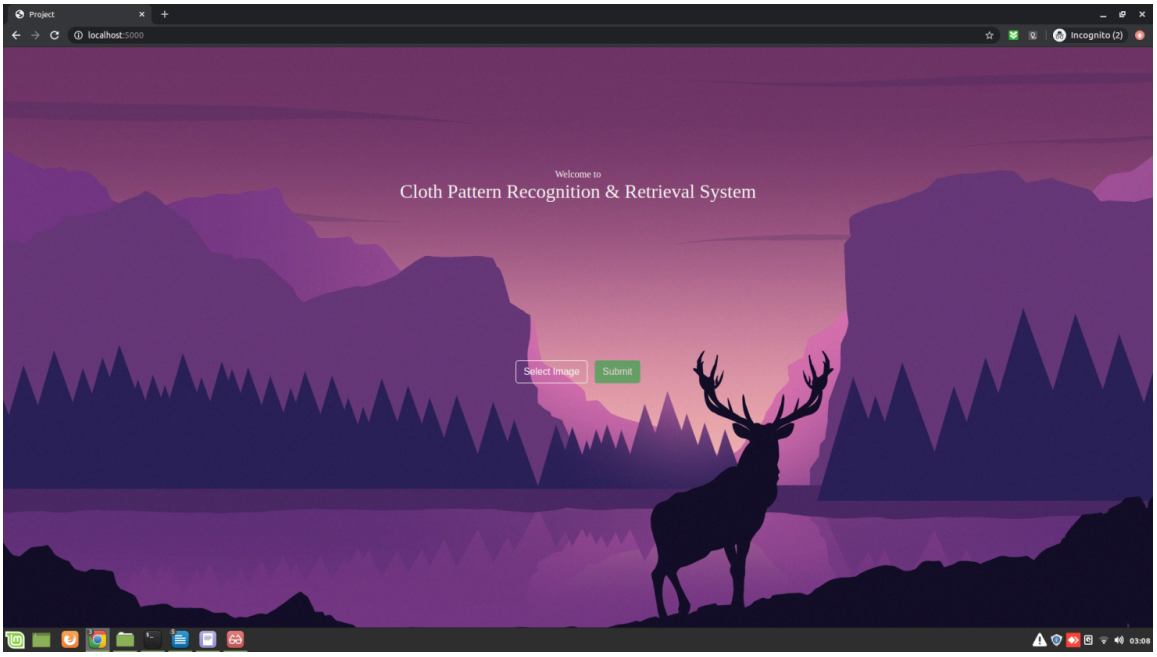

Figure 5.1: Home Page.

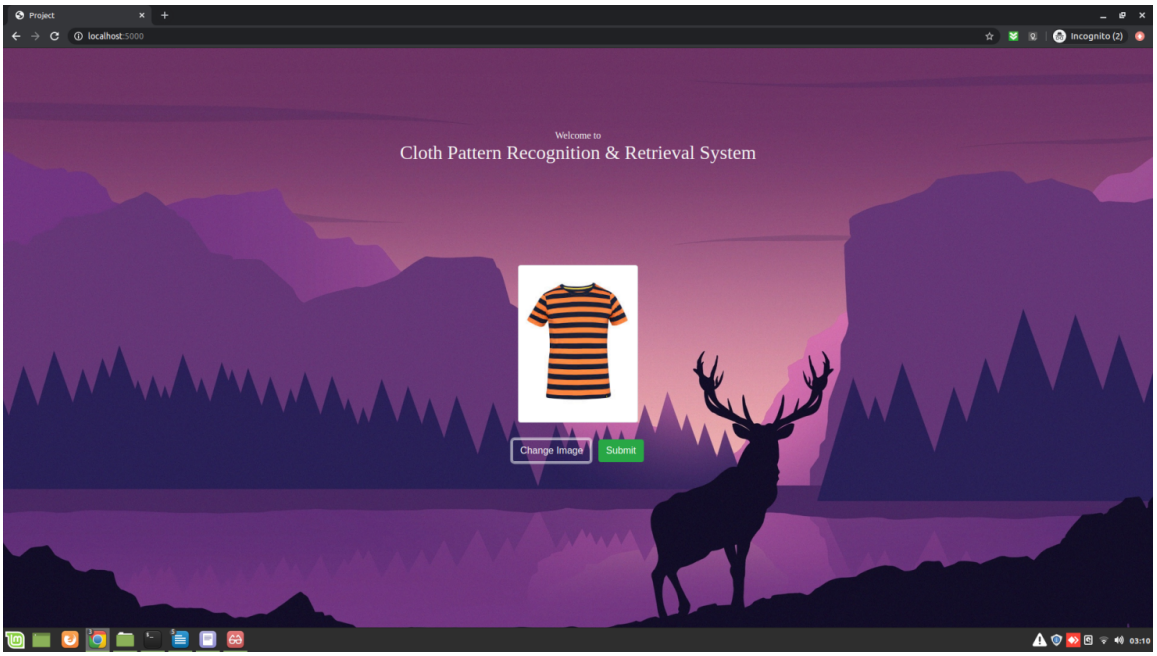

Figure 5.2: Upload Image.

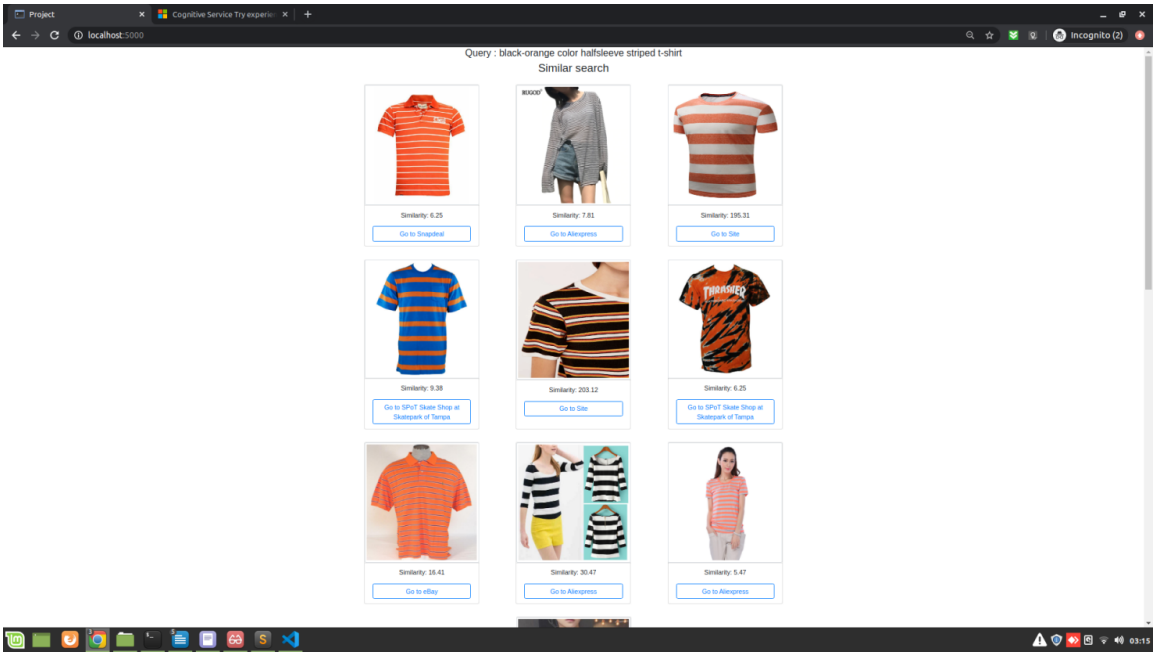

Figure 5.3: Unfiltered Results.

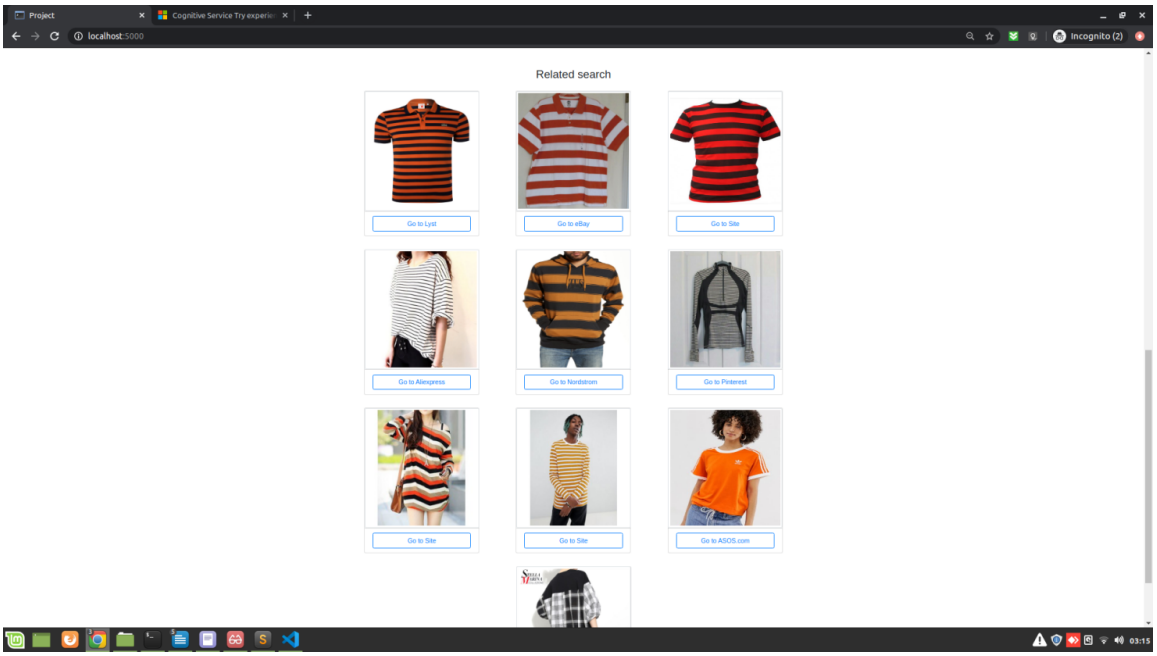

Figure 5.4: Filtered Results.

Chapter 6

Conclusion & Future Work

Online Product searching has been limited to traditional methods and can be enhanced further using AI and Image Processing due abundance of data and increase in DL research and Computer processing over the years. Our system provides a small demonstration of such a system using an example of clothes but core ideas and principles can be expanded to many similar applications. The performance of system can further be increased by using segmentation to separate object from the background before providing it to DL models for attribute prediction. Increasing the quality of dataset or using augmentation techniques can also help in improving the accuracy of models.

Appendix - I

Installation Procedure

1. Cloning the repo:
   $ git clone https://github.com/priteshsatpute/deepfashion.git or download the zip file
2. Installing Dependencies:
   $ cd deepfashion
   $ python setup.py
3. To start the server run this command in terminal or cmd to start the project:
   $ python server.py
4. Project will run on port 5000. Go to `http:localhost:5000/`

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Cloth Pattern Recognition & Retrieval System

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***Abstract*—The aim of our project is to design a system where user can find similar clothes from online retailers such as Amazon, Flipkart, Myntra, and other E-commerce websites based on input image to the system. The image is captured by the camera and get processed to identify the pattern, color, collar type, text and sleeve type of the respective image. This can be classified using the pritesh add kar algorithm. For this the features of the image have to be obtained. These features can be extracted using the pritesh add kar. After identifying the features query is generated. The generated query is then given to bing api. The system uses the Clothing Pattern dataset categorized in plaid, striped, solid and irregular. However, cloth recognition algorithms are often confronted with 3 fundamental challenges when adopted in real world applications i.e. clothes often have large variations in styles, textures and patterns; clothing items are frequently subject to deformations and occlusions; clothing images often exhibit serious variations when they are taken in different scenarios such as low light, different orientation, camera quality and unfavorable ambience. Thus, through our project we try to develop the above aforementioned system while considering the challenges.**

***Index Terms*—Computer Vision, Artificial Intelligence, Deep Learning**

I. Problem Formulation

To provide an efficient algorithm that is both effective and economical in performing cloth pattern detection task and retrieval from web without compromising on lighting, wrinkles or orientational parameters.

II. Introduction

In the past decade, there has been a dramatic change in the way consumers have altered their way of shopping. Although consumers continue to purchase from a physical store, consumers feel very convenient to shop online since it frees the customer from personally visiting the store. Most search functions on fashion retail sites currently rely on objective data, such as colors, patterns, collar type, etc., to filter their products. Fashion: An Object and a Process. "Fashion" may be conceptualized both as an object and as a behavioral process. The critical characteristics of a fashion, both as an object and a process, are defined. A fashion is a culturally endorsed form of expression, in a particular material or non-material phenomenon, which is discernible at any given time and changes over time within a social system or group of associated individuals [1]. Conversion rates in fashion range from 1.85% to 2.4% and vary extensively based on product complexity, sales value, checkout ease, market niche, etc. Improving the conversion rate is a long-term process and a constant challenge, where understanding buying journeys (right customers engaging at the right point in their buying cycle) and tracking profitability in detail are key. Well-defined and comprehensive product categories that allow visual product search is demand and need of fashion market [2]. Visual search is taking the retail world by storm. When customers perform a visual search, they look for a product using an image instead of keywords. In the rapidly reducing attention spans of the digital age, visual search capabilities play an integral role in capturing the imaginations of customers. It is now easier than ever for customers to find items they want to purchase online or discover items they want to purchase. A lot of the future of search is going to be about pictures instead of keywords.

III. Comparison between the algorithms

Pattern recognition aims to classify data (patterns) based on either a priori knowledge or on statistical information extracted from the patterns. The patterns to be classified are usually groups of measurements or observations, defining points in an appropriate multidimensional space. During the last few years the researchers have proposed many mathematical approaches to solve the pattern recognition problems. Recognition strategies heavily depend on the nature of the data to be recognized. The available methods of pattern recognition may be categorized into two basic principles: 1.Statistical Methods: consisting the sub disciplines like discriminate analysis, feature extraction, error estimation, cluster analysis Neural Networks based Methods Statistical Methods of Pattern Recognition:

This is an approach to machine intelligence which is based on statistical modelling of data. In a statistical model, one applies probability theory and decision theory to get an algorithm. The three major issues encountered in the design

of a statistical pattern recognition system are sensing, feature extraction, and classification. The primary issue is the representation of the input data which can be measured from the objects to be recognized and it is called sensing problem.

The number of features of the pattern samples is usually very large. The features of the pattern samples are reduced by considering their salient characteristics. This process is referred to as feature extraction. The last issue of the statistical pattern recognition is the pattern classification or development of the classifier. The pattern classifier is defined as a device or a process that sorts the given data into identifiable categories and classes. Trainable classifier is one that can improve its performance in response to the information it receives as a function of time. Training is a process by which the parameters of the classifiers are adjusted. The classifier is trained using the reduced pattern samples. It is often assumed that the pattern samples of a given class occupy a finite region in a pattern space and it is called a class region.

On comparing statistical and neural pattern recognition techniques we realize that how neural techniques are much far better than statistical techniques. Neural Network Based Methods: The pattern recognition approaches discussed so far are based on direct computation through machines. The neural approach applies biological concepts to machines for pattern recognition. The outcome of this effort is invention of artificial neural networks. Neural networks can be viewed as massively parallel computing systems consisting of an extremely large number of simple processors with many interconnections. Neural network models attempt to use some organizational principles (such as learning, generalization, adaptively, fault tolerance, distributed representation, and computation) in a network of weighted directed graphs in which the nodes are artificial neurons and directed edges (with weights) are connections between neuron outputs and neuron inputs. The main characteristics of neural networks are that they have the ability to learn complex nonlinear input-output relationships, use sequential training procedures, and adapt themselves to the data. The increasing popularity of neural network models to solve pattern recognition problems has been primarily due to their seemingly low dependence on domain-specific knowledge (relative to model-based and rule-based approaches) and due to the availability of efficient learning algorithms. Neural networks provide a new suite of nonlinear algorithms for feature extraction (using hidden layers) and classification (e.g., multilayer perceptron's). In addition, existing feature extraction and classification algorithms can also be mapped on neural network architectures for efficient (hardware) implementation.

The second type of approach focuses on content-based image retrieval (CBIR), where images are automatically indexed and retrieved with low level content features like colour, shape and texture. In image classification and retrieval, images are represented using low level features. Because an image is an unstructured array of pixels, the first step in semantic understanding is to extract efficient and effective visual features from these pixels. Appropriate feature representation significantly improves the performance of the semantic learning techniques. Image segmentation is usually the first step to extract region-based image representation. The segmentation algorithm divides images into different components based on feature homogeneity. A number of segmentation approaches exist in the literature, such as grid based, clustering based, contour based, model based, graph based, and region growing based method. Image segmentation plays an important role in the screening of medical imaging. In the last decades, fuzzy segmentation methods, especially the fuzzy c-means algorithm, have been widely used in the image segmentation and such a success chiefly attributes to the introduction of fuzziness for the belongingness of each image pixel .This allows for the ability to make the clustering methods able to retain more information from the original image than the crisp or hard segmentation methods.

IV. Motivation

Brands are also tapping into visual search to give customers a gentle nudge to continue shopping when they are tempted to navigate away from the eCommerce website. The beauty of visual search is that it can ignite the imagination, then stoke and capture the resulting purchase intent. Visual search will inevitably disrupt the eCommerce industry significantly in the years to come. Customers are disappointed when they visit a website and find that the product they want to purchase is out of stock. Often, they will close the tab, or navigate to another website that features something similar. Streamlining the booking process through a powerful visual search mechanism helps to close the gap between wanderlust and reality.

A. Why Visual Search Matters

Humans are incredibly visual creatures. We identify images within 13 milliseconds, and 90% of all the information received by the brain is visual. Currently, only 8% of retailers have built-in image search into their e-commerce sites; however, recent studies in both the US and the UK have shown that 62% of millennials want visual search capabilities more than any other new technology [4]. These statistics, coupled with the increased use of social media for product discovery, is an indicator that retailers and brands must optimize image content to ensure they future-proof themselves for visual search. So much of the way people naturally want to shop is far better served by visual search than it is by text search or site-navigation.

1) Key Takeaways:

- Increased product discovery accuracy as well as conversion to purchase by combining text-based and visual search.
- Marketers will be able to gain better insights into customer motivations and, more importantly, habits to provide a more tailored experience [5].

Pinterest launched its visual search functionality back in 2015, which is now used to complete 600 million visual searches every month, up 140% year-on-year. This has enabled Pinterest to build a very healthy ad-based business with an

8.5% conversion rate, allowing brands to target over 5,000 categories — a powerful tool to enable personalized marketing. Image recognition solutions allow customers to scan a picture taken from a fashion magazine or a print ad and instantly land to the product page where they can buy that exact item. Customers can finally forget about scanning QR codes, looking up links manually, or tediously searching for specific brand names or describing clothing items in the store or search engine.

V. Improving the search experience and its efficiency

Online shoppers can upload an image to the site, or take a picture in an app, to look for similar products in the Retailer's catalog in a blink of an eye. This paves the way for much better product discovery experience, as shoppers don't need to wander through endless sub-categories to find that leopard print furry coat – especially that in many cases they may not even know how it's called what they are looking for.

1) Find Less Expensive, Similar, Pieces of Clothing: At some point in our lives, we all have fallen in love with an item, but found it too expensive to buy. With visual search solutions running in the app or website, Retailers can suggest similar-looking items in different price ranges, so the customer can buy a look-alike product at a lower price. This feature can become a staple in e-commerce sites, as it can be used to offer relevant recommendations, based on items the shopper looked at but didn't buy. Of course, Retailers can also use such solutions to upsell to the customer, showing higher value alternatives that look alike.

2) Automated Tagging OR Categorizing: Visual recognition in fashion helps pre-categorize all the clothing items, saving the time and money of doing it all manually, and avoiding human errors [6].

3) Minimize User Browsing Time: When it comes to online shopping, users are browsing more and buying less. Shoppers look across various sites for clothes. According to data from the survey, two-thirds of consumers on average (66%) say they have specific product in mind and look for just that.

4) Increase Conversion Rate: Allowing user to find and locate clothes alternative across various sites, thereby increasing conversion rate.

5) Poor Search Engine: Customers choose shopping online to avoid waiting or queuing when shopping in store. So there is no reason for them to keep waiting when shopping online just because the website loads slowly and has poor searching engine. Most consumers search for several minutes in a category before selecting one or more products for purchase. If navigation is not smooth, they will end up getting tired and leaving the site, leaving behind an abandoned shopping cart. This is one of the problems faced by e-commerce consumers when shopping online [3].

VI. Methodology

1) Pattern Recognition: Pattern recognition is concerned primarily with the description and classification of measurements taken from physical or mental processes. Our discussion is based on the above loose definition. In order to provide an effective and efficient description of patterns, preprocessing is often required to-remove noise and redundancy in the measurements. Then a set of characteristic measurements, which could be numerical and/or nonnumerical, and relations among these measurements, are extracted for the representation of patterns. Classification and/or description of the patterns with respect to a specific goal is performed on the basis of the representation. The many different mathematical techniques used to solve pattern recognition problems may be grouped into two general approaches. They are the decision-theoretic (or discriminant) approach and the syntactic (or structural) approach. In the decision-theoretic approach, a set of characteristic measurements, called features, are extracted from the patterns. Each pattern is represented by a feature vector, and the recognition of each pattern is usually made by partitioning the feature space. On the other hand, in the syntactic approach, each pattern is expressed as a composition of its components, called sub patterns or pattern primitives. This approach draws an analogy between the structure of patterns and the syntax of a language. The recognition of each pattern is usually made by parsing the pattern structure according to a given set of syntax rules. In some applications, both of these approaches may be used.

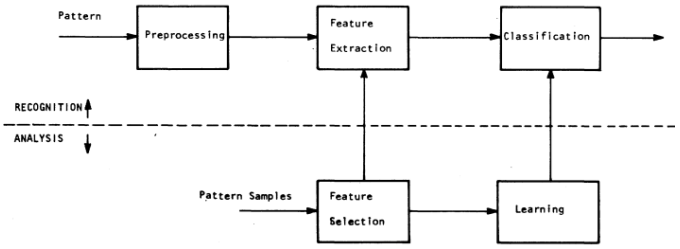

Fig. 1. Block Diagram of a Decision Theoretical Pattern Recogntion System. [7]

The Overall System Architecture can be divided into following steps:

- Pre-processing the image for any noise: The aim of digital image processing is to improve the image data (features) by suppressing unwanted distortions and/or enhancement of some important image features so that our AI-Computer Vision models can benefit from this improved data to work on. Images captured by a camera and fed to our algorithms vary in size, therefore, we establish a base size of 250 x 250 DPI for all images fed into our algorithms. Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. Gaussian smoothing is also used as a pre-processing stage in if size of input image is greater than 3MB .
- Extracting various features from the image: We are using an ensemble approach for extracting various features such as pattern, sleeve type, collar type, colour of the T-shirt

and Text on the T-shirt. Ensemble methods is a machine learning technique that combines several base models in order to produce one optimal predictive model. Since we are only focused on T-shirts the various features used are: Colour, Pattern, Sleeve type, Collar type, Text.

- Using the features list for formulating a Query: Based on the features extracted from the image a query will be formulated which will be used to retrieve data from online e-commerce site like bing.com.
- Retrieving the results using the query: The query will be given to bing api which will return response to that query.
- Finding Similarity index between result images and input image: We will find the similarity index between the input image and the image retrieved from bing api.

2) Feature Extraction For Clothing Pattern Recognition: Some clothing patterns present as visual patterns characterized by the repetition of a few basic primitives (e.g., plaids or stripes). Accordingly, local features are effective to extract the structural information of repetitive primitives. However, due to large intra-class variance, local primitives of the same clothing pattern category can vary significantly (see Fig. I). Global features including directionality and statistical properties of clothing patterns are more stable within the same category. Therefore, they are able to provide complementary information to local structural features.

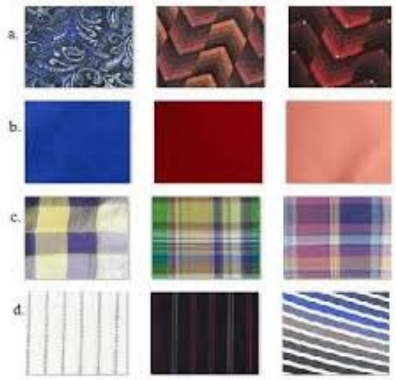

Fig. 2. Intra-Class Variations.

(a) Irregular
(b) Solid
(c) Plaid
(d) Striped

Clothing images present large intra-class variations, which result in the major challenge for clothing pattern recognition. However, in a global perspective, the directionality of clothing patterns is more consistent across different categories and can be used as an important property to distinguish different clothing patterns. Our system can recognize clothing patterns into four categories (plaid, striped, pattern-less, and Irregular). It is able to identify all primary, secondary and tertiary colors.

3) Finding Dominant Colors: We are using K-means to find three most dominant colors in the image. Kmeans algorithm is an iterative algorithm that tries to partition the dataset into K pre-defined distinct non-overlapping subgroups (clusters) where each data point belongs to only one group. It tries to make the inter-cluster data points as similar as possible while also keeping the clusters as different (far) as possible.

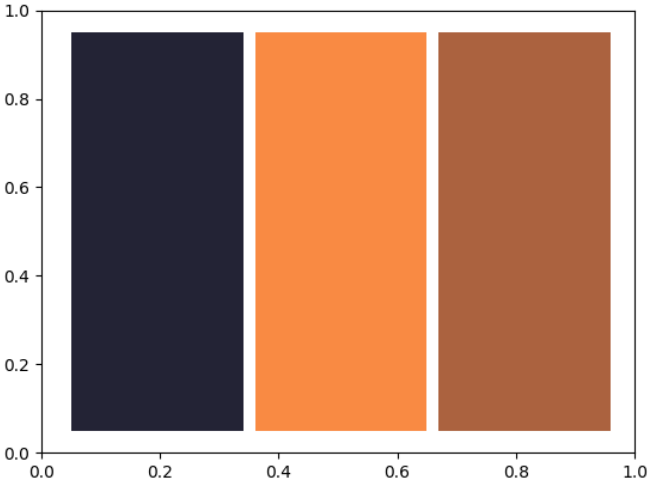

Fig. 3. Dominant Colors.

4) Finding Color Names: It assigns names to a dominant color such that the sum of the squared distance between the RGB value of the reference color names and the dominat color (euclidean distance) is at the minimum.

5) Locating Text: We are using OpenCV's EAST text detector. Which is a deep learning model, based on a novel architecture and training pattern. It is capable of

1) running at near real-time at 13 FPS on 720p images and
2) obtains state-of-the-art text detection accuracy

The text sections in the image are located and then cropped before feeding to OCR for obtaining text. We are using Tesseract engine to perform Optical character recognition. It works by finding templates in pixels, letters, words and sentences. It uses two-step approach that calls adaptive recognition. It requires one data stage for character recognition, then the second stage to fulfil any letters, it wasn't insured in, by letters that can match the word or sentence context. We are also using Bing OCR as tesseract performs poorly under noisy backgrounds and changeing fonts and colors. Combining output of two OCR furthur improves the overall accuracy of identifying text.

6) Query Formulation: Flow Diagram of Query Formulation

7) Finding Similarity Index: Top 10 Images obtained from Bing API are downloaded and then compared with the users input image to find the similarity between the two. For which we have used SIFT algorithm. The scale-invariant feature transform (SIFT) is an algorithm used to detect and describe local features in digital images. It locates certain key points and then furnishes them with quantitative information (so-called descriptors) which can for example be used for object recognition. A key point is the position where the feature

Fig. 4. Text Location.

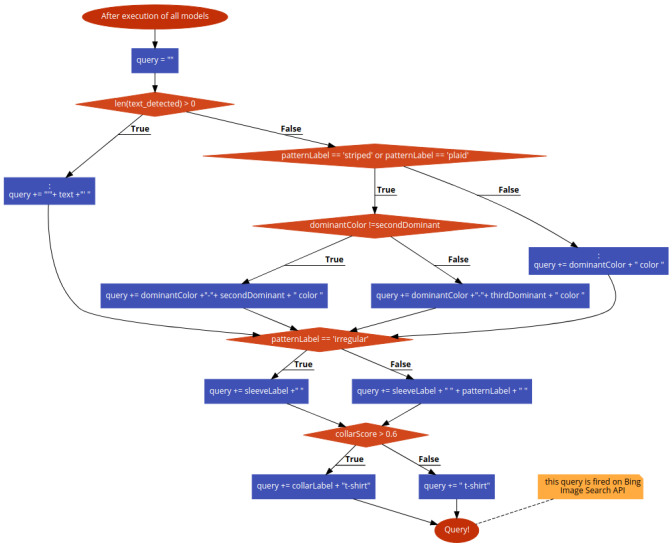

Fig. 5. Query Formulation.

has been detected, while the descriptor is an array containing numbers to describe that feature. When the descriptors are similar, it means that also the feature is similar

VII. Clothing Pattern Dataset

This dataset includes 4000 images of four different typical clothing pattern designs: plaid, striped, patternless, and irregular with 1000 images in each category. The resolution of each image is down-sampled to 140×140. In addition to illumination variances, scaling changes, rotations, and surface deformations presented in the traditional texture dataset, clothing patterns alsodemonstrate much larger intraclass pattern and color (intensity) variations, which augment the challenges of recognition.

VIII. Results & Discussion

In order to retrieve similar clothes online, we have built a prediction system that predicts the various attributes from input cloth image and forms a query based on parameters like colour, pattern, sleeve type etc. The average accuracy of all the models is 86.11%. The individual accuracy of the models is 87.3% for sleeve model, 82% for collar model and 88.75% for pattern model. The overall success rate of the system in formulating the query based on a random sample of 20 images is 60%. The search results obtained after formulation of a query from Bing image search API are uncertain and dubious. The similarity index helps to eliminate the problem to some extent but its computationally very expensive and time consuming hence its impossible to check every image from the search result.

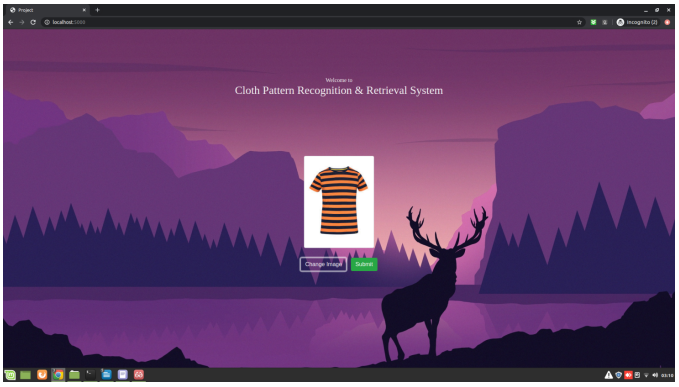

Fig. 6. Upload Image.

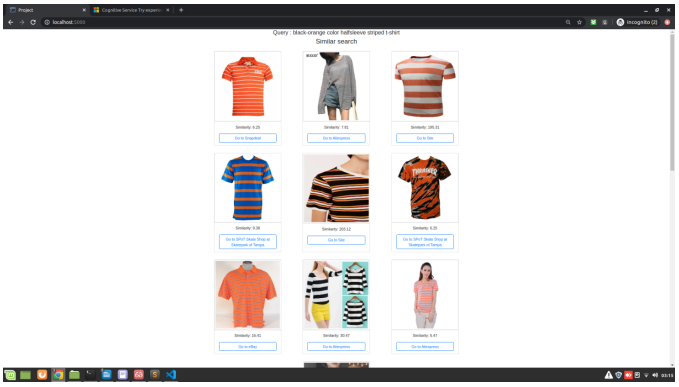

Fig. 7. Results.

IX. Conclusion & Future Work

Online Product searching has been limited to traditional methods and can be enhanced further using AI and Image Processing due abundance of data and increase in DL research and Computer processing over the years. Our system provides a small demonstration of such a system using an example of clothes but core ideas and principles can be expanded to many similar applications. The performance of system can further be increased by using segmentation to separate object from the background before providing it to DL models

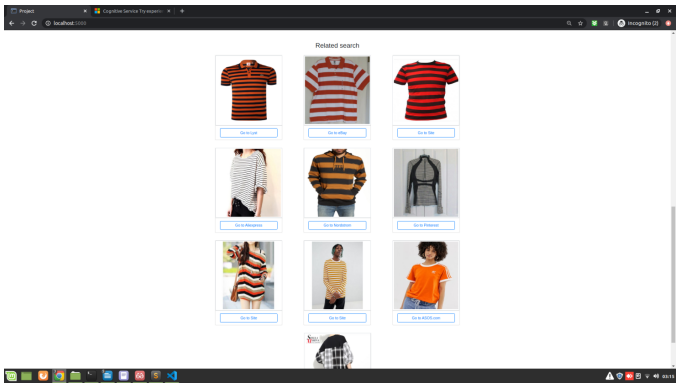

Fig. 8. Filtered Results.

for attribute prediction. Increasing the quality of dataset or using augmentation techniques can also help in improving the accuracy of models.

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It is certified that Project Report Titled “Cloth Pattern Recognition & Retrieval System” by Jayesh Kukreja, Pritesh Satpute and Ankit Vishwakarma has been thoroughly examined. We undertake the following:

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