

# Final - TFLite

- Complete pipeline for Visual Similarity based Fashion Item Recommendation Engine, but utilizing quantized Tensorflow Lite Models instead of Tensorflow-Keras Models
- Except for the Fashion Object Localization Model (Yolov5) which is a pytorch model, all the Tensorflow Keras models have been transformed to Tensorflow Lite models, yielding smaller models and faster inference speeds.

In [1]:

```
import os
import numpy as np
import pandas as pd
from tqdm import tqdm
import tensorflow as tf
from PIL import Image
from tensorflow.keras.models import load_model
from tensorflow.keras.applications import resnet
import matplotlib.pyplot as plt
from skimage import io
%cd .\yolov5
from detect import generate_bbox
%matplotlib inline
```

C:\Users\CHIRAG\Desktop\DataScience\AAIC\Notes\Case\_Studies\Mynta\yolov5

In [2]:

```
BATCH_SIZE = 1
TARGET_SHAPE = (224, 224, 3)
EMBEDDING_DIMENSION = 256
LOADED_MODELS = dict()
LOADED_CSVS = dict()
```

In [3]:

```
class TFLiteModel:
    """
    Generic Class to load initialize and predict using Tensorflow Lite Models
    """
    def __init__(self, model_path, batch_size=BATCH_SIZE, input_shape=TARGET_SHAPE, output_shape=(EMBEDDING_DIMENSION,)):
        """
        Initialize interpreter, allocate input and output tensors
        """
        self.interpreter = tf.lite.Interpreter(model_path=model_path)
        self.input_details = self.interpreter.get_input_details()
        self.output_details = self.interpreter.get_output_details()
        self.interpreter.resize_tensor_input(self.input_details[0]['index'], (batch_size,) + input_shape)
        self.interpreter.resize_tensor_input(self.output_details[0]['index'], (batch_size,) + output_shape)
        self.interpreter.allocate_tensors()
        self.input_details = self.interpreter.get_input_details()
        self.output_details = self.interpreter.get_output_details()

    def __call__(self, X):
        """
        Invoke the Tensorflow Lite model with the provided input and produce predictions/outputs
        """
        self.interpreter.set_tensor(self.input_details[0]['index'], X)
        self.interpreter.invoke()
        y = self.interpreter.get_tensor(self.output_details[0]['index'])
        return y

    def preprocess_image1(filename):
        """
        Load the specified file as a JPEG image, preprocess it and
        resize it to the target shape for Gender Classification
        """
        image_string = tf.io.read_file(filename)
        image = tf.image.decode_jpeg(image_string, channels=3)
        image = tf.image.resize(image, TARGET_SHAPE[:2])
        return tf.expand_dims(image, axis=0)

    def preprocess_image2(filename):
        """
        Load the specified file as a JPEG image, preprocess it and
        resize it to the target shape for Embedding Generation
        """
        image_string = tf.io.read_file(filename)
        image = tf.image.decode_jpeg(image_string, channels=3)
        image = tf.image.convert_image_dtype(image, tf.float32)
        image = tf.image.resize(image, TARGET_SHAPE[:2])
        image = resnet.preprocess_input(image)
        return tf.expand_dims(image, axis=0)

    def load_models():
        """
        Load Various Models for Recommendation Engine Pipeline
        """
        if len(LOADED_MODELS) == 4:
            return True
        else:
            print("Loading Models...")
            GENDER_CLASSIFIER = TFLiteModel(model_path="..\TFLite_MODELS\gender_classifier.tflite", output_shape=(1,))
            TOPWEAR_EMBEDDING = TFLiteModel(model_path="..\TFLite_MODELS\topwear.tflite")
            BOTTOMWEAR_EMBEDDING = TFLiteModel(model_path="..\TFLite_MODELS\bottomwear.tflite")
            FOOTWEAR_EMBEDDING = TFLiteModel(model_path="..\TFLite_MODELS\footwear.tflite")

            LOADED_MODELS["gender_classifier"] = GENDER_CLASSIFIER
            LOADED_MODELS["topwear"] = TOPWEAR_EMBEDDING
            LOADED_MODELS["bottomwear"] = BOTTOMWEAR_EMBEDDING
            LOADED_MODELS["footwear"] = FOOTWEAR_EMBEDDING
```

```

print("Models Loaded!")
return True

def load_CSVs():
"""
Load Various CSV files for Embedding Generation Pipeline
"""
if len(LOADED_CSVS) == 6:
    return True
else:
    print("Loading CSVs...")
    MENS_TOPWEAR_CSV = pd.read_csv("../\\CSVs\\mens_topwear_embeddings.csv")
    MENS_BOTTOMWEAR_CSV = pd.read_csv("../\\CSVs\\mens_bottomwear_embeddings.csv")
    MENS_FOOTWEAR_CSV = pd.read_csv("../\\CSVs\\mens_footwear_embeddings.csv")
    WOMENS_TOPWEAR_CSV = pd.read_csv("../\\CSVs\\womens_topwear_embeddings.csv")
    WOMENS_BOTTOMWEAR_CSV = pd.read_csv("../\\CSVs\\womens_bottomwear_embeddings.csv")
    WOMENS_FOOTWEAR_CSV = pd.read_csv("../\\CSVs\\womens_footwear_embeddings.csv")

    LOADED_CSVS["mens_topwear"] = MENS_TOPWEAR_CSV
    LOADED_CSVS["mens_bottomwear"] = MENS_BOTTOMWEAR_CSV
    LOADED_CSVS["mens_footwear"] = MENS_FOOTWEAR_CSV
    LOADED_CSVS["womens_topwear"] = WOMENS_TOPWEAR_CSV
    LOADED_CSVS["womens_bottomwear"] = WOMENS_BOTTOMWEAR_CSV
    LOADED_CSVS["womens_footwear"] = WOMENS_FOOTWEAR_CSV
    print("CSVs Loaded!")
    return True

def extract_clothes(image):
    """
    Extract Topwear, Bottomwear and Footwear from a given Image
    Note: In case there are multiple items of the same class, the item with highest confidence score is returned.

    Args:
        image: Path to the image file that you want to extract clothes from.

    Returns:
        outputs: Dict[numpy.ndarray], Dictionary containing detected Object Class as Keys and the image slice as Values. Also contains the original image.
    """
    temporary_image_storage = False
    if isinstance(image, str):
        img_path = image
        image = io.imread(img_path)
    elif isinstance(image, np.ndarray):
        img_path = os.path.join("static", "images", "example.jpg")
        saved_image = Image.fromarray(image)
        saved_image.save(img_path)
        temporary_image_storage = True
    results = generate_bbox(img_path, conf_thres=0.3)
    if temporary_image_storage:
        os.remove(img_path)
    topwear_score, bottomwear_score, footwear_score = 0, 0, 0
    outputs = {"original_image": image}
    for result in results[0]:
        XMIN, YMIN, XMAX, YMAX = result[2]
        if (result[0] == 'Topwear') and (result[1] > topwear_score):
            topwear_score = result[1]
            outputs["topwear"] = image[YMIN:YMAX, XMIN:XMAX]
        elif (result[0] == 'Bottomwear') and (result[1] > bottomwear_score):
            bottomwear_score = result[1]
            outputs["bottomwear"] = image[YMIN:YMAX, XMIN:XMAX]
        elif (result[0] == 'Footwear') and (result[1] > footwear_score):
            footwear_score = result[1]
            outputs["footwear"] = image[YMIN:YMAX, XMIN:XMAX]
    return outputs

def plot_clothes(**images):
    """
    Plot a dictionary of Images in a row

    Args:
        Dict: Image Names and Images in numpy.ndarray format

    Returns:
        matplotlib.figure object
    """
    n = len(images)
    plt.figure(figsize=(16, 5))
    for i, (name, image) in enumerate(images.items()):
        plt.subplot(1, n, i + 1)
        plt.axis("off")
        plt.title(''.join(name.split('_')).title())
        plt.imshow(image)
    plt.show()

def generate_embedding(outputs, detected_objects):
    """
    Generate Embeddings for Cropped Outputs from the Object Detection Module

    Args:
        outputs: Dict[] objects containing Image slices for cropped detections
        detected_objects: List[] names of the detected objects like topwear, bottomwear and footwear

    Returns:
        outputs: Outputs with embeddings for each detected objects.
    """
    for output in detected_objects:
        image = outputs[output]
        img_path = os.path.join("static", "images", "example.jpg")
        saved_image = Image.fromarray(image)

```

```

    saved_image.save(img_path)
    image = preprocess_image2(img_path)
    embedding = LOADED_MODELS[output](image)[0].astype(np.float32).tolist()
    outputs[output + "_embedding"] = embedding
    os.remove(img_path)
return outputs

def __get__(csv_file, query):
    """
    Plot Top 10 similar products for each category along with the Product Link.
    """
    csv_file['distance'] = csv_file['embedding'].apply(lambda x: np.linalg.norm(np.asarray(eval(x), dtype=np.float32) - np.asarray(query, dtype=np.float32)))
    csv_file = csv_file.sort_values(by='distance').reset_index(drop=True)
    result = csv_file.iloc[:10][['product_url', 'image_url']].to_dict('records')
    for i, row in csv_file.iloc[:10].iterrows():
        plt.figure(figsize=(16, 9))
        image = io.imread("../" + row["image_url"])
        plt.imshow(image); plt.axis("off"); plt.show()
        print("Shop Now @ ", row["product_url"])
        print(254 * "=")
    return result

def get_results(outputs, gender, detected_objects):
    """
    Get Similar products for a given input containing query product.
    """
    dict_results = dict()
    for output in detected_objects:
        csv_file = gender + "_" + output
        csv_file = LOADED_CSFS[csv_file].copy(deep=True)
        query = outputs[output + "_embedding"]
        dict_results[output] = __get__(csv_file, query)
    return dict_results

def final(images):
    """
    The complete pipeline for recommending similar fashion products based on a query image.
    """
    if isinstance(images, str):
        images = [images]
    if load_models() and load_CSFS():
        for img_path in images:
            inputs = preprocess_image1(img_path)
            gender_score = LOADED_MODELS["gender_classifier"]([inputs])[0][0]
            gender = "mens" if gender_score < 0.5 else "womens"
            outputs = extract_clothes(img_path)
            detected_objects = [k for k in outputs if k != "original_image"]
            plot_clothes(**outputs)
            outputs = generate_embedding(outputs, detected_objects)
            results = get_results(outputs, gender, detected_objects)

```

In [9]: `img_path = "../\google-image-search-database\womens_casual_top_wear\707be93f8e.jpg"`  
`final(img_path)`





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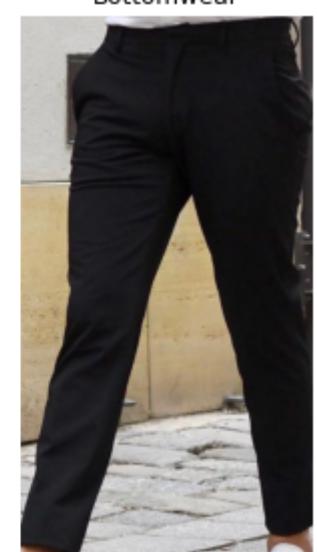
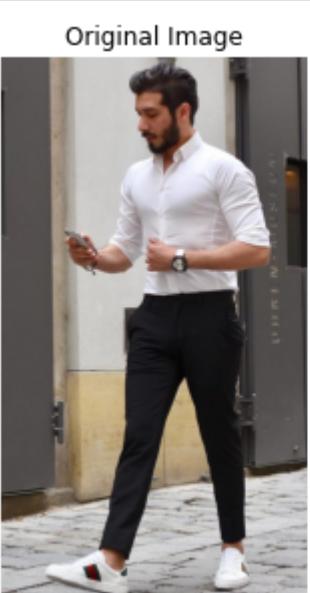


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```
In [6]: img_path = "..\\google-image-search-database\\mens_formal_top_wear\\3cf46ceef5.jpg"
final(img_path)
```





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In [7]: img_path = "..\\google-image-search-database\\womens_casual_top_wear\\dd35ba9fdd.jpg"
final(img_path)
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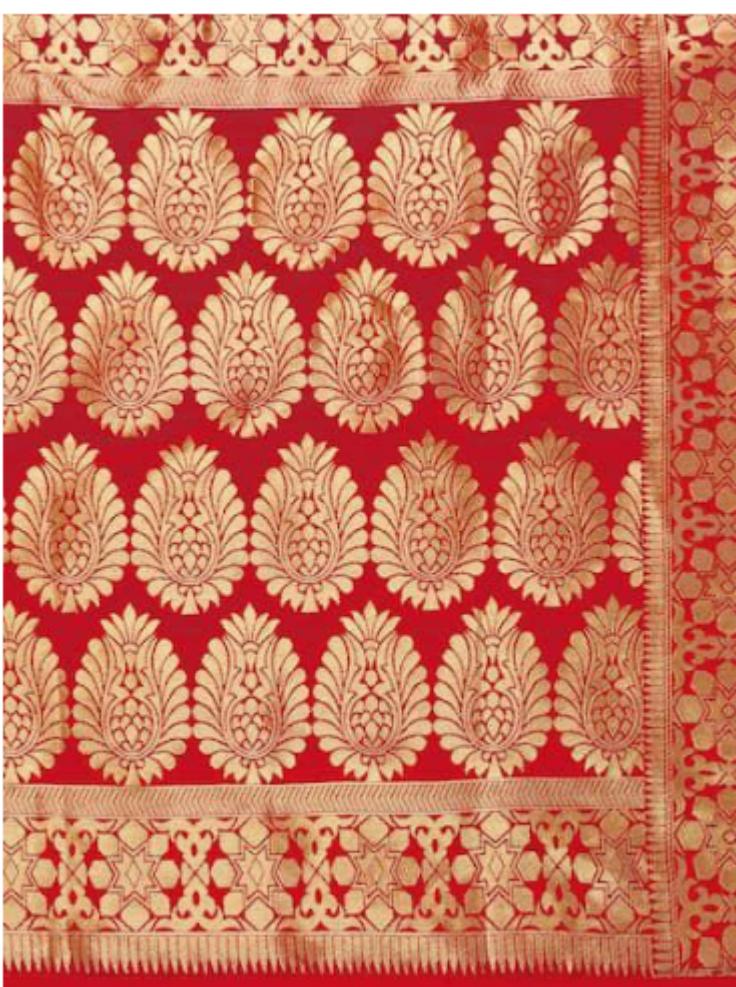
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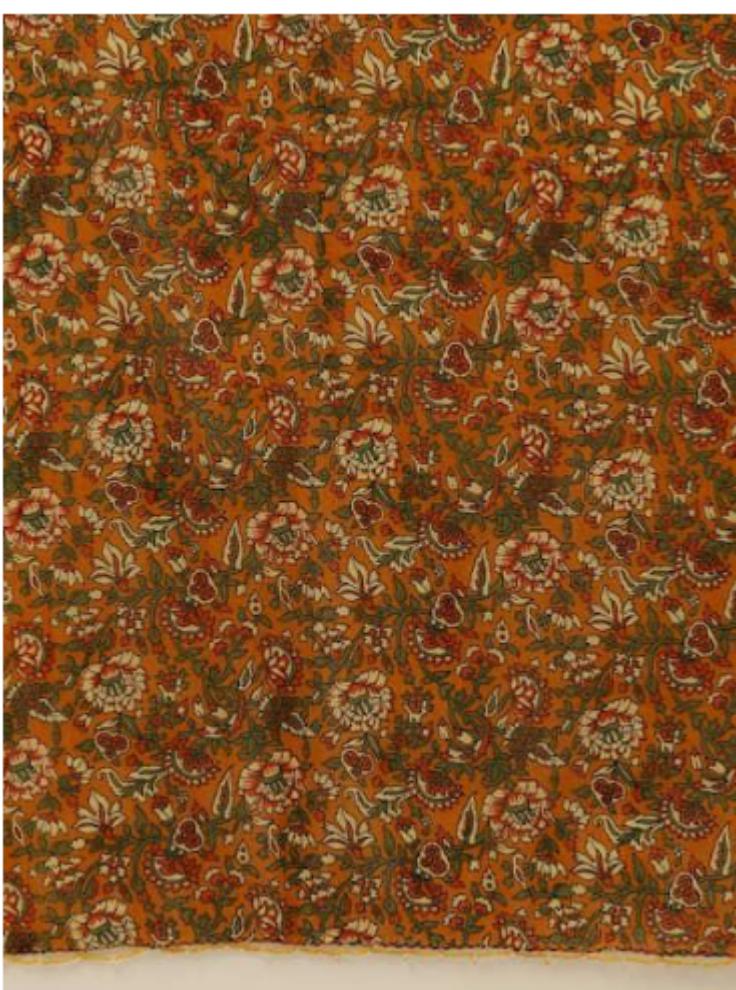
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Shop Now @ <https://www.myntra.com/trousers/sassafras/sassafras-women-brown--white-twill-weave-tapered-fit-high-rise-checked-trousers/12541522/buy>

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Shop Now @ <https://www.myntra.com/trousers/parx/parx-women-white-regular-fit-striped-regular-trousers/13222214/buy>

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Shop Now @ <https://www.myntra.com/palazzos/klotthe/klotthe-women-pack-of-2-black--pink-striped-wide-leg-palazzos/13766702/buy>

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Shop Now @ <https://www.myntra.com/trousers/dodo--moa/dodo--moa-women-navy-blue-regular-fit-striped-regular-trousers/13862746/buy>



Shop Now @ <https://www.myntra.com/trousers/trend-arrest/trend-arrest-women-multicoloured-straight-fit-striped-parallel-trousers/11637282/buy>

```
In [8]: img_path = "..\\google-image-search-database\\mens_formal_top_wear\\f6c91729cb.jpg"
final(img_path)
```



Original Image



Footwear



Topwear



Bottomwear



Shop Now @ <https://www.myntra.com/flip-flops/franco-leone/franco-leone-men-white--blue-printed-sliders/13142676/buy>

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Shop Now @ <https://www.myntra.com/flip-flops/carlton-london/carlton-london-men-brown-solid-sliders/13407998/buy>

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Shop Now @ <https://www.myntra.com/flip-flops/adda/adda-men-black-colourblocked-sliders/12077324/buy>

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Shop Now @ <https://www.myntra.com/formal-shoes/rapawalk/rapawalk-beige--black-handcrafted-standard-width-leather-slipons/7286875/buy>

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Shop Now @ <https://www.myntra.com/formal-shoes/khadims/khadims-men-brown-colourblocked-british-walkers-leather-formal-oxfords/11939424/buy>

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Shop Now @ <https://www.myntra.com/formal-shoes/rapawalk/rapawalk-beige--coffee-brown-handcrafted-standard-width-leather-slipons/7305585/buy>

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Shop Now @ <https://www.myntra.com/formal-shoes/rapawalk/rapawalk-beige--coffee-brown-handcrafted-wide-width-leather-slipons/7305590/buy>

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Shop Now @ <https://www.myntra.com/flip-flops/san-frisco/san-frisco-men-black-solid-sliders/13491644/buy>

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Shop Now @ <https://www.myntra.com/casual-shoes/sko/sko-men-sea-green-leather-slip-on-sneakers/11525248/buy>

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Shop Now @ <https://www.myntra.com/sandals/bata/bata-men-black-comfort-sandals/12421004/buy>

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Shop Now @ <https://www.myntra.com/shirts/mast--harbour/mast--harbour-men-navy-blue--white-regular-fit-geometric-printed-casual-shirt/12934534/buy>

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Shop Now @ <https://www.myntra.com/shirts/jainish/jainish-men-grey-classic-slim-fit-self-design-formal-shirt/3117522/buy>

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Shop Now @ <https://www.myntra.com/shirts/roadster/roadster-men-grey--black-regular-fit-reversible-casual-shirt/2220375/buy>

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Shop Now @ <https://www.myntra.com/shirts/highlander/highlander-men-navy-blue--grey-slim-fit-striped-casual-shirt/6713009/buy>

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Shop Now @ <https://www.myntra.com/shirts/the-indian-garage-co/the-indian-garage-co-men-navy-blue--brown-slim-fit-checked-casual-shirt/13467804/buy>

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Shop Now @ <https://www.myntra.com/shirts/wrogn/wrogn-men-black-slim-fit-printed-casual-shirt/10187679/buy>

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Shop Now @ <https://www.myntra.com/shirts/wrogn/wrogn-men-blue--brown-slim-fit-checked-casual-shirt/2032637/buy>

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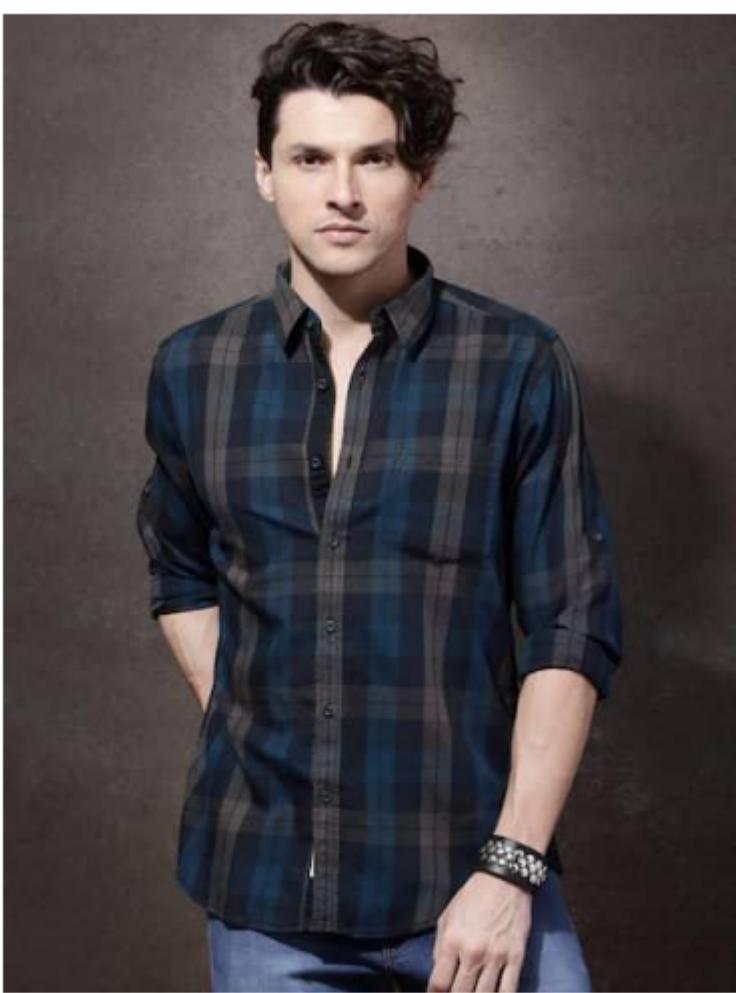
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Shop Now @ <https://www.myntra.com/shirts/wrogn/wrogn-men-burgundy-slim-fit-solid-casual-shirt/10187555/buy>

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Shop Now @ <https://www.myntra.com/shirts/roadster/roadster-men-navy--grey-checked-casual-shirt/1667044/buy>

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Shop Now @ <https://www.myntra.com/shirts/wrogn/wrogn-men-navy--maroon-slim-fit-checked-casual-shirt/8426181/buy>

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Shop Now @ <https://www.myntra.com/trousers/suitltd/suitltd-charcoal-grey-striped-slim-fit-formal-trousers/1747286/buy>

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Shop Now @ <https://www.myntra.com/trousers/hancock/hancock-men-navy-blue--white-slim-fit-checked-formal-trousers/12319054/buy>

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Shop Now @ <https://www.myntra.com/track-pants/gracit/gracit-men-pack-of-2-solid-dry-fit-track-pants/13854720/buy>

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Shop Now @ <https://www.myntra.com/trousers/park-avenue/park-avenue-men-blue-regular-fit-solid-knitted-formal-trousers/10516106/buy>

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Shop Now @ <https://www.myntra.com/trousers/peter-england/peter-england-men-black-slim-fit-solid-formal-trousers/13956524/buy>

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Shop Now @ <https://www.myntra.com/trousers/blackberrys/blackberrys-men-navy-blue--white-narrow-fit-checked-formal-trousers/11861448/buy>

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Shop Now @ <https://www.myntra.com/trousers/park-avenue/park-avenue-men-navy-blue-checked-regular-fit-formal-trousers/10938184/buy>

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Shop Now @ <https://www.myntra.com/trousers/peter-england/peter-england-men-black-slim-fit-solid-formal-trousers/13841404/buy>

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Shop Now @ <https://www.myntra.com/trousers/peter-england/peter-england-men-navy-blue-slim-fit-solid-formal-trousers/10806372/buy>

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Shop Now @ <https://www.myntra.com/trousers/park-avenue/park-avenue-men-black-regular-fit-solid-formal-trousers/7721249/buy>

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- The model sizes were significantly reduced thanks to Quantization, which in turn led to faster inference but the embeddings generated by the quantized models aren't able to generate the effective recommendations that the earlier pipeline did.
- However it has to be noted that further advanced Quantization and pruning techniques like (Training aware Quantization) could provide better results while also maintaining smaller and faster models.