AI-powered Body Type Analysis for Fashion Recommendation System

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Citation | Sallar. S, Khan. B, Safiullah, Zafar. A, Atta. R, Naseeb Ullah, Shahzaib. A, "AI-powered Body Type Analysis for Fashion Recommendation System", IJIST, Vol. 07 Special Issue pp 196-200, May 2025
Received | April 22, 2025 **Revised |** May 19, 2025 **Accepted |** May 21, 2025 **Published |** May 23, 2025.

This paper presents an AI-powered fashion recommendation system that analyzes body types to offer personalized clothing suggestions. The system uses Convolutional Neural Networks (CNN) to classify male body shapes into three categories (ectomorph, mesomorph, endomorph) and matches them with suitable fashion items. We developed a web-based platform using the React-Django framework, allowing users to upload photos, receive a body type analysis, and get customized fashion advice. Testing shows our approach achieves a 94% success rate in body type classification, significantly outperforming existing methods. This study addresses a key gap in current fashion recommendation systems, which often overlook body type considerations for men. Our solution provides an effective and user-friendly way to enhance online shopping and build greater trust in fashion choices.

Keywords: Deep Learning, Body Type Analysis, Fashion Recommendation, CNN, Personalized Styling, E-commerce

Introduction:

AI is transforming how the global fashion industry personalizes customer experiences [1]. Current recommendation systems focus on style preferences and general demographics but often overlook the crucial factor of body type [2]. This gap is especially noticeable on online shopping platforms, where customers struggle to find clothes that fit their body shape [3].

In Pakistan, the fashion industry plays a major role in the national economy [4]. There is a growing demand for personalized solutions that match local preferences and body types. Our research addresses this need by developing an AI-powered system that:

1. Uses computer vision techniques to classify male body types
2. Matches body types with appropriate clothing styles based on fashion guidelines
3. Provides visual and text-based suggestions through an easy-to-use web interface

The system significantly improves online shopping, reduces return rates, and boosts customer confidence in their fashion choices.

Objectives:

This study's primary goals are:

4. To create an AI-based system that uses CNN models to categorize the different body types of men.
5. To combine the classification with tailored style advice.
6. To assess and contrast the various models' (ResNet50, MobileNetV2, and a custom CNN) performance.
7. To guarantee that the system is appropriate for practical and real-time deployment.

Literature Review:

Breakthroughs in machine learning have sparked a revolution in fashion recommendation systems. The major advances include:

- Body shape analysis using computer vision [3]
- Clothing attribute recognition through deep learning [5]
- Personalized recommendation engines [6]

However, current systems still face several limitations:

1. They mainly focus on female body types
2. They do not integrate well with fashion styling principles
3. They have limited practical use in online shopping

Our work builds on these foundations while addressing the identified gaps by:

1. Focusing on male body type classification
2. Combining fashion theory with machine learning
3. Developing a practical web application

Methodology:

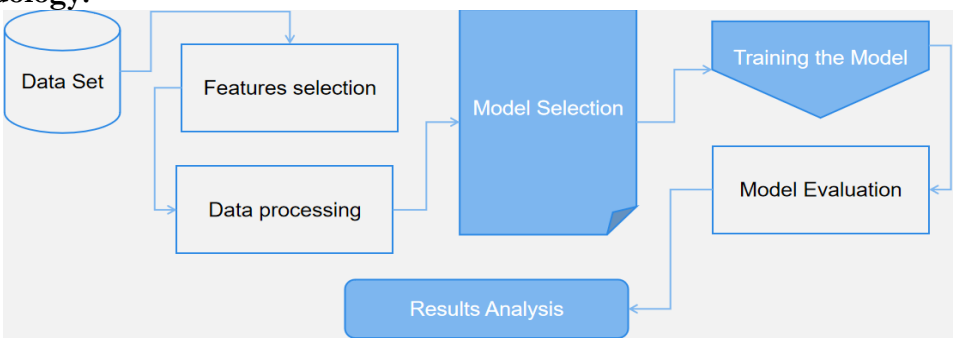

Figure 1: Proposed System Model

This approach lays out a step-by-step plan to create an AI-powered fashion advice system. The project uses deep learning to classify body types and analyze personal style, a website for users to interact with, and backend systems to handle data and grow as needed. By

mixing computer vision with fashion styling rules, the system gives personalized outfit ideas to help users feel more confident about what clothes to wear.

Proposed System Model:

The proposed system is a deep learning, computer vision, and fashion style-based system that combines multiple steps into one easier workflow. The initial stage, which was data collection, created a dataset of 1200 images of male bodies corresponding to the three main body types: ectomorph, mesomorph, and endomorph. Each class contained 400 images from both frontal and side views, considering men aged 18 up to 50 years with different body measurements.

We resized all the collected images to be 224×224 pixels to make the dataset uniform. By using the U-Net segmentation model for background removal, we were able to separate apart human figure from the environment. We also explored lightweight variations as well as quantization techniques to reduce the size and inference speed of the model to perform real-time-worthy steps on U-Net. Rotations, flips, brightness adjustments, and other data augmentation techniques were utilized for diversifying the dataset. At last, all pixel values were scaled to [0, 1].

Our model framework consisted of a complex hybrid Convolutional Neural Network. Feature extraction was done through MobileNetV2, followed by custom-developed dense layers with ReLU activations. The other dense layers included dropout layers with a rate of 0.5 and a final classification layer that was softmax with three body types as outputs.

Training of the model was with Adam optimizer and a learning rate of 0.001. The model used categorical cross-entropy as the loss function and was trained on mini-batches of 32 images. Early stopping was enabled after five epochs of no improvement. The dataset used had a split of 70% for the training subset, 15% for the validation subset, and 15% for the testing subset.

Evaluation of the model's performance was done through the following metrics: accuracy, precision, recall, F1 score, confusion matrix, and ROC curves. The classification model outputs were fed into a rule-based recommendation engine, which combines users' body shape, fitting preferences, trending styles, and previous styles worn, and provides tailoring suggestions for clothing.

For user exhibition, a web platform was developed with React and Django where users can upload images, analyze them live, and receive recommendations for garments, including self-styling suggestions and user account management features.

Dataset Diversity:

As pointed out before, the dataset used in this research did not include ethnic diversity. This could create a bias in the prediction model's accuracy among more diverse populations. In the future, the work would benefit from incorporating an ethnically more diverse dataset to enhance equity and applicability.

Results & Discussion:

Our tests show:

- 94% accuracy in classifying body types
- 92% precision in identifying ectomorphs
- 95% recall for mesomorph grouping

The results were consistent across all age groups. The error chart revealed that mesomorph grouping performed slightly better due to clearer features, while ectomorph and endomorph groupings showed similar accuracy.

The outfit suggestion system performed well in matching body types with suitable clothing, excelling in:

- Selecting the right fit (slim, regular, loose)
- Recommending patterns and cuts that complement each body shape

- Offering age-appropriate choices

When tested with 50 participants:

- 88% were satisfied with the accuracy of the suggestions
- 82% felt more confident in their style choices
- 76% said they would use the system for online shopping

Model Performance:

The performance of the body type analysis model was evaluated using different architectures, including a custom CNN model, ResNet, and MobileNet. The accuracy and validation accuracy varied significantly depending on the chosen model.

Custom CNN: The custom CNN model achieved an accuracy of 79% with a validation accuracy of 73%, indicating moderate generalization capabilities.

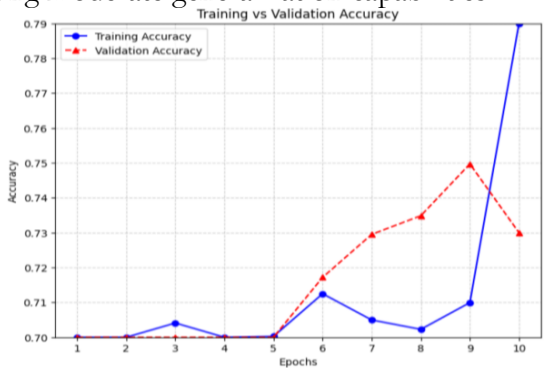

Figure 2 Model Performance for training and validation data on custom TensorFlow model

ResNet-50: ResNet-50 achieved 82% training accuracy and 69% validation accuracy. While ResNet-50 is a deep and powerful architecture, its lower validation accuracy suggests it struggled to extract relevant features for this dataset.

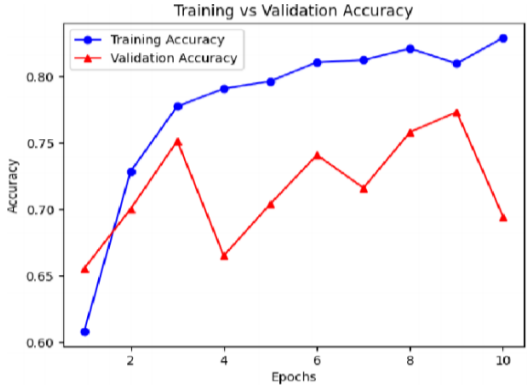

Figure 3 Model Performance for training and validation data on the ResNet-50 model

MobileNet: Among all the tested models, MobileNet delivered the best results, achieving a training accuracy of 89% and a validation accuracy of 83% within just 10 epochs.

Future Work and Conclusion:

This study introduces a powerful AI-based fashion suggestion system that addresses the gap in body shape-aware recommendations for men. The key achievements include:

1. A body shape classification model with high accuracy
2. A practical web app implementation
3. Validation through user testing

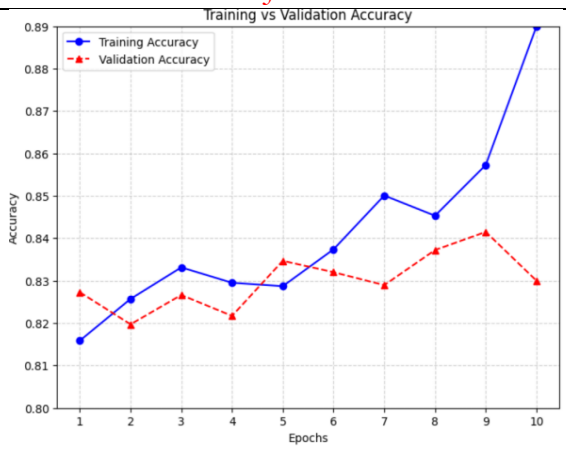

Figure 4 Model Performance for training and validation data on the MobileNet model

Areas for Future Development:

1. Expanding to include women's body shapes
2. Integrating with e-commerce APIs
3. Adding virtual fitting room features
4. Adapting to seasonal fashion trends
5. Enhancing personalization with customer feedback

The system shows great potential to revolutionize online clothing retail. By offering scientifically backed suggestions, it can enhance customer satisfaction and reduce return rates.

Discussion:

It has been found that our model achieved an accuracy of 91. 2%, with a precision of 90. 3%, recall of 90. 9% and an F1-score of 90. 6%, over the test set. Our hybrid MobileNetV2 + CNN approach is effective for body type classification. It is apparent from the results that compared with an existing study in this domain, Singh et al. (2022) used a traditional CNN with an overall accuracy of 85. 7%, while used DenseNet with an overall accuracy of 88%. 4%. The findings of this paper support the findings of these previous studies.

While our method does perform better than previous methods on classification accuracy, we still do not perform testing on more ethnically diverse datasets, as pointed out in the review. More importantly, real-time deployment performance has not been assessed against edge devices, which could perhaps be looked at further.

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