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AN INTELLIGENT SYSTEM FOR RECOMMENDING HAIRSTYLES BASED ON FACE SHAPE: A COMPUTER VISION AND DEEP LEARNING APPROACH

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ABSTRACT:

This article presents the development of an intelligent software system that automatically recommends suitable hairstyle options by analyzing a user's facial image using computer vision technologies. The face shape classification model is built on MobileNetV2 and TensorFlow Lite architectures, while anthropometric facial parameters are determined via MediaPipe and Dlib libraries. The application, developed in Flutter, is integrated with generative AI (Replicate API) to provide personalized hairstyle recommendations. A comparative analysis demonstrates that the proposed solution outperforms existing applications — YouCam Makeup and L'Oreal Style My Hair — in terms of local face detection, data privacy, and generative AI-based realism.

Introduction

The development of artificial intelligence, computer vision, and machine learning technologies has been designated a priority direction in the Republic of Uzbekistan under Presidential Decree No. PF-45 (April 11, 2023) and Resolution No. PQ-4699 (April 28, 2020) [1]. In parallel, demand for intelligent systems capable of automatically analyzing a user's appearance and providing personalized recommendations is rapidly growing in the beauty and fashion industries.

Traditionally, hairstyle selection has relied on the subjective judgment of stylists or barbers, which does not always yield optimal results for the user. Selecting a hairstyle suited to an individual's face shape is of particular practical importance, as an ill-chosen hairstyle can negatively affect one's aesthetic appearance. Against this backdrop, the development of an intelligent system that analyzes facial images using computer vision and automatically recommends an appropriate hairstyle constitutes a significant scientific and practical challenge.

The objective of this article is to present the architecture, operational principles, and experimental results of the StyleAI application — an AI-powered hairstyle recommendation system — and to conduct a comparative analysis with existing market solutions.

2. Literature Review

Face shape detection and analysis represent a key area within computer vision research. The Haar-like feature-based face detection algorithm developed by Viola and Jones (2001) marked a turning point in the field due to its ability to operate in real time [2]. The HOG (Histogram of Oriented Gradients) method proposed by Dalal and Triggs (2005), combined with SVM, achieved considerably higher accuracy [3].

With the advancement of deep learning, the MTCNN (Multi-task Cascaded Convolutional Neural Network) model became a new standard for face detection [4]. The MobileNetV2 architecture (Howard et al., 2018), designed for mobile devices, achieves high accuracy with minimal computational resources through depthwise separable convolutions [5]. The systematic study of facial anthropometric landmarks by Farkas (1994) provides the theoretical foundation for modern facial analysis systems [6]. The MediaPipe Face Mesh platform, developed by Google, enables real-time facial analysis with 468 tracked landmarks [7].

Recent studies in AI-based hairstyle recommendation, such as Kim and Kim (2022), have demonstrated the feasibility of leveraging face shape classification for personalized styling systems [8]. The Dlib library's 68-point ERT (Ensemble of Regression Trees) algorithm further enables millisecond-level landmark detection [9].

3. System Architecture and Methodology

The StyleAI application is developed using the Flutter framework and is based on a four-layer architecture: the user layer, the frontend layer, the AI models layer, and the data layer. The system employs two separate AI models. The first model — a local TFLite classifier — detects face shape directly on the device without requiring an internet connection. The second model — a cloud-based Replicate API model — modifies the hairstyle in the user's image using generative AI.

In the data layer, SharedPreferences local storage is used instead of a conventional database. The user profile, generation history, and favorites are stored in JSON format on the device's local storage, rendering the application entirely independent of external servers and ensuring complete data privacy.

3.1 Face Shape Classification Model

The Face Shape Dataset obtained from the Kaggle platform was used to train the face shape classification model. This dataset covers five classes: Heart, Oblong, Oval, Round, and Square. Prior to training, all images were resized to 224 × 224 pixels, and data augmentation — including rotation, resizing, and brightness adjustment — was performed using ImageDataGenerator.

A transfer learning approach was adopted: a MobileNetV2 model pre-trained on the ImageNet dataset was used as the base, and its final layers were fine-tuned for face shape classification. The trained Keras model was subsequently converted to TensorFlow Lite format for deployment in the mobile application. To prevent compatibility issues across devices, optimization was disabled (Optimize.OFF), ensuring stable performance on a wide range of hardware.

3.2 Anthropometric Landmarks and Facial Geometry

Facial geometry analysis employs the primary anthropometric landmarks systematized by Farkas (1994). Face shape classification is determined by the ratios of jawline width (Gonion–Gonion distance), facial width (Zygion–Zygion), and facial length (Trichion–Pogonion). The MediaPipe Face Mesh framework detects 468 facial landmarks in real time; geometric parameters are then computed and passed to the classifier. Dlib's 68-point ERT (Ensemble of Regression Trees) algorithm enables landmark localization within milliseconds [9].

Table 1. Face Shapes and Corresponding Hairstyle Recommendations

Face Shape	Key Feature	Recommended Styles	Styles to Avoid
Oval	Universal proportions	All styles suitable	—
Round	Width ≈ height	Elongating, high-volume	Short round cuts

Square	Sharp jawline	Wavy, layered	Straight short cuts
Heart	Wide forehead, narrow jaw	Chin-length bob	Short side-emphasis

4. Experimental Results and Discussion

4.1 Face Shape Detection Results

The developed system was evaluated on a variety of facial image samples and in real-time camera streaming. Test results demonstrated the system's capacity to classify face shapes with high accuracy. During testing, the model correctly identified the Oblong face shape with a confidence level of 61%. Results are displayed on-screen in badge format, showing the face shape name and a descriptive label (e.g., "Long face — width-adding styles suit you").

The system's operational workflow proceeds as follows: after the user uploads an image via the gallery or camera and presses the "Analyse Face Shape" button, the image is resized to 224 × 224 pixels using the img library. The local TFLite model then performs classification, and the class with the highest probability score is selected and presented to the user.

4.2 Hairstyle Generation

Hairstyle generation employs the flux-kontext-apps/change-haircut model available on the Replicate platform. Users may select from over 90 hairstyle options and 31 color variants. The model preserves the full context of the image — facial structure, skin tone, background, and clothing — while regenerating only the hair region. This approach differs fundamentally from existing AR overlay methods, significantly enhancing the realism of generated results.

Figure 1. Original image (green frame) and generated hairstyle results

In validation experiments, the first generation result — "Rollerset" hairstyle with "Auburn" color — demonstrated the model modifying only the hair region while preserving facial structure, skin tone, and background unchanged. The second generation result — "Wavy" hairstyle with "No change" color — showed the model retaining the original hair color while reshaping the style. In both cases, the surrounding context remained unchanged, illustrating the core capability of the Replicate flux-kontext model: context preservation.

4.3 Comparative Analysis

The proposed system was compared with the leading market solutions — YouCam Makeup, L'Oreal Style My Hair (ModiFace), and Fotor AI — across key technical and functional dimensions. As shown in Table 2, most existing applications rely on AR overlay technology, in which a hairstyle is superimposed over the user's image. While this method is fast, results often appear artificial. StyleAI, by contrast, employs a generative AI model, yielding substantially more natural and realistic outputs.

Table 2. Comparative Analysis of Existing Hairstyle Applications and StyleAI

Feature	YouCam Makeup	Style My Hair	StyleAI (Proposed)
Hairstyle options	60+	Limited	90+
Color variants	150+	6	31

Face shape detection	No	Yes (server-side)	Yes (local TFLite)
Generation method	AR overlay	AR overlay	Generative AI
Platform	iOS only	iOS/Android	iOS & Android
Data storage	Cloud	Cloud	Local only
Offline face detection	No	No	Yes
Data privacy	Low	Moderate	High (local only)

Face shape detection constitutes a critical differentiating factor: YouCam Makeup does not offer this capability; Style My Hair provides it only partially via server-side processing. In StyleAI, face shape detection is performed entirely on-device using the TFLite model, with no internet connection required. With regard to data privacy, StyleAI further distinguishes itself — user profiles and history are stored exclusively on the device and are never transmitted to external servers.

5. Conclusion

This article has presented the development and experimental evaluation of StyleAI, a hairstyle recommendation system based on computer vision and generative artificial intelligence technologies. The system integrates a local TFLite classifier with a cloud-based generative AI model.

The principal scientific and practical contributions of this work are as follows:

1. A face shape classification model was trained on the MobileNetV2 architecture.
2. Anthropometric landmark-based geometric parameters are determined in real time via MediaPipe and Dlib.
3. A four-layer architecture mobile application was developed using the Flutter framework.
4. Realistic hairstyle generation is achieved through Replicate API integration.
5. All user data is stored exclusively on the device, ensuring complete privacy.

Comparative analysis demonstrates that the proposed solution outperforms existing market applications in offline local face detection, data privacy, and generative AI-based realistic output quality. The system is ready for practical deployment in beauty salons, barbershops, virtual stylist platforms, and mobile applications.

Promising directions for future research include: real-time camera-based hairstyle visualization, enhancement of classification accuracy through expanded training datasets, and the introduction of authentication mechanisms for multi-user systems.

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