

The Role of Artificial Intelligence in Curly Hair Analysis

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Abstract

Curly Girl Method (CGM) is a routine dedicated to curly hair to help individuals understand the nature of their hair and deal with it without causing harm to it. The main idea is to keep the hair away from harsh ingredients such as sulphates and silicone, so that the curly hair is defined naturally and healthy.

The problem is that choosing curly hair products is a difficult process because the chemical ingredients that should be avoided are difficult for individuals who are not familiar with chemistry to identify them, in addition to the process of balancing protein and moisturising the hair requires time and experience to know the hair condition and choose a suitable product that achieves this balance. From this perspective, this research focuses on exploring how artificial intelligence techniques can analyse hair from images and determine its status and products suitable for it according to CGM

Introduction

The world has recently witnessed significant developments in the field of artificial intelligence (AI), and we see its strong presence in many fields, including beauty, and many applications have emerged, such as camera-based skin analysis tools. This has highlighted the need to use AI in hair analysis, as it is a fundamental element of a person's identity. However, hair care, especially curly hair, remains a challenge, due to the curly hair wide variety of textures and it requires specific routines and products that are completely different from straight or wavy hair.

This research aims to explore the role of AI in analyzing curly hair and customizing appropriate products.

Background

The Curly Girl method is a curly hair care routine created by hairdresser Lorraine Massey to help curly-haired people bring out their natural curls instead of fighting them with straightening and strong ingredients. The basic principle of this method is to avoid strong ingredients that dry the hair, such as strong shampoos full of sulfates and silicone and use gentle ingredients to deal with hair.

Cgm starts by choosing products carefully, by reading the ingredients written on the product to avoid harmful and unapproved ingredients in this method, such as Sodium Lauryl, Laureth Sulphate, Dimethicone, Amodimethicone, etc. Many people cannot distinguish these ingredients because of the difficulty of their scientific names; therefore, they face difficulty in choosing products. There are currently sites and apps such as isitcg and curlsbob provide service to indicate whether a product is a cgm approved or not, but the matter does not stop here, the cgm is based on the principle that the health of curly hair starts from a balance between moisturising and protein, a simple principle that states that hair needs water and moisturising to be Soft, and need protein to remain strong and cohesive, so there must be a balance between these two factors, and to achieve this balance, the hair and the texture of curls must be monitoring and tracking to understand what it needs and restore the balance with appropriate products, and this is a rather difficult process for beginners because curls vary from one individual to another due to the different type of curls pattern and the different conditions on hair. So it would be nice to have a

personal assistant who gives a diagnosis of the hair and serves as a flexible guide to help the individual understand their hair and recommend products based on that.

Problem Statement:

Curly hair is one of the hair types that face challenges in care routine and choosing appropriate products due to the variety of its textures (it varies from 2 to 4 with subcategories from a to c). Although there are some classification systems that help to identify curl patterns and needs, such as Andre Walker System, the Form Inclination Arrangement (FIA Typing) and LOIS Systems, but they do not provide an accurate analysis of each hair type. Besides, many companies produce their products without any specific analysis or understanding of hair characteristics, which leads to the uselessness of their products for some users.

Recently, the world has witnessed significant developments in the field of artificial intelligence (AI), and we see its presence in the previous papers. However, curly hair remains a challenge, due to the wide variety of textures and it requires specific routines and products.

Despite this, most currently available intelligent systems lack sufficient analysis for this hair type. Most databases that used to train algorithms contain images of people with straight or wavy hair, which make curly hair analysis results inaccurate or not specifically designed for the person. Given the importance of this topic, this research aims to explore the role of AI in analyzing curly hair and customizing appropriate products according to the Curly Girl Method (CGM).

Research Objectives:

This research aims to solve the problem of accuracy of curly hair analysis and products recommendation using AI, which has been discussed in the problem statement. The research objectives are built around the primary objective, and each objective is structured in such a way as to improve real-world hair analysis accuracy.

1. To analyze previous papers and research in hair analysis, especially curly hair type, and assess current systems used to deal with this kind of hair variant texture.
2. To evaluate challenges in analyzing curly hair texture and characteristics.
3. To study challenges accompanies using AI technology in cosmetics and hair care routine specially.
4. To propose a model built with AI capable of analyzing curly hair and customizing appropriate products according to the Curly Girl Method (CGM)

Research Scope

1. This research will focus on the analysis and classification of curly hair using artificial intelligence techniques.
2. The analysis includes different curly hair types (wavy, curly, coils).

3. This research will focus on the classification of hair and suggesting products based on that.
4. This research will not involve any medical and laboratory experiments; I will focus on image analysis and machine learning algorithms.

Summary research papers [Literature reviews]:

Paper 1: Artificial Intelligence in Hair Research: A Proof-of-Concept Study on Evaluating Hair Assembly Features

This paper presents the use of artificial intelligence (AI) to evaluate the effect of hair care products on hair volume, straightness, and flyaways, this done by analyzing images of straight hair treated with different products, using machine learning algorithms, 2D image analysis, and human tests for comparison. It explains why hair shape and appearance are important, and demonstrates that consumers are interested in modifying hair to suit their taste. It also mentions that companies produce variant hair care products to determine their effectiveness and they conduct evaluation tests often performed by manual human visual assessments, which are sometimes inaccurate.

This study has two main objectives, first one is to use computer vision and machine learning techniques to measure the effect of treatments on hair assembly, so that it is possible to identify whether hair volume has increased or its appearance has changed after a particular treatment, and the second one is to compare the performance of AI with human assessments. It also demonstrates that shape, size, and flyaway are not just aesthetic, but also result from physical and chemical properties, thus reinforcing the importance of automated analysis tools such as AI to measure these properties more precisely.

Paper 2: Towards Creation of a Curl Pattern Recognition System

This paper proposes an automated system for classifying curl patterns using computer vision and convolutional neural networks (CNNs). The goal is to build a model that recognizes hair patterns from an image, then uses this classification to recommend appropriate hair care products.

The system utilizes established systems for classifying curly hair:

- **Andre Walker System**: the primary system used to classify hair into four main categories each with subcategories.

- **LOIS System and FIA System**: alternative models that offer more comprehensive classification using additional features such as volume, density, shine, etc.

To collect various hair images they used web scraping tools, as well as images taken from 30 volunteers. The images were then processed and converted to grayscale after that to binary images. By using “Active Shape Models” features were extracted and trained on a CNN model fed with 30x30 pixel images. The system was able to recognize curl patterns and recommend appropriate products based on the pattern.

Paper 3: Reimagining Hair Science: A New Approach to Classify Curly Hair Phenotypes via New Quantitative Geometrical & Structural Mechanical Parameters

This paper aims to reimagine curly hair classification using new and accurate geometric and mechanical measurements instead of traditional classifications based solely on external appearance and general appearance, such as the Andre Walker or L'Oréal systems.

The paper shows that traditional systems are insufficient to distinguish the differences within curly and coily hair types, which are a challenge users face when choosing appropriate products. Therefore, it aims to develop a new system based on precise geometric measurements such as the total length of the hair path (L), number of curls, pitch, diameter, and ellipticity (e), in addition to mechanical properties such as the tensile stress-strain relationship until the hair is stretched and breaks. It seeks to link these properties to hair type and appropriate products.

This study was conducted by collecting real hair samples from female volunteers at Spelman College with curly and coil hair. The researchers used precision instruments such as scanning electron microscopy (SEM), photogrammetry, tensile strength analyzer (TA), and dynamic mechanical analyzer (DMA) to measure hair shape, the number of bends per 3 cm (contours), the length-to-bend ratio (contour/pitch), and the stress-strain relationship. The results showed that curly and kinky hair have different properties that influence their performance and response to products. And they proposed a new quantitative classification system based on these geometric values.

Paper 4: High-throughput phenotyping methods for quantifying hair fiber morphology

Morphology is the science that studies the structure and shape of organisms, and the morphology of hair varies between individuals and people, and is often described in terms such as hair type, hair shape or hair texture (pattern). These descriptions may be inaccurate and depend on visual estimates instead of quantitative measurement, as this estimate may vary from person to person. A new measurement method has been proposed and developed to reduce human intervention. This method does not require high technical skills and is done through high-resolution imaging and automated image analysis.

In this paper, the researchers developed a Python package called fibremorph, which extracts bending and eccentricity from longitudinal and transverse sections

of hair images. This package does not need user programming and provides clear instructions for using it. Fibremorph is an essential tool that allows accurate measurement of hair specifications, where hair curvature is calculated scientifically instead of relying on visual observation.

The researchers collected a sample of 140 people of European and African origin, and their hair curves were quantifiably compared with the classification of hair patterns (straight, wavy, curly). Then the accuracy of this package was tested by simulating 100 samples, and the error rate was very low. The researchers adopted a protocol for hair stabilisation and made cross-sections from it, where they used heat-resistant plastic sheets of polycaprolactone, heating plates, metal moulds, cutting tools, and accurately represented the curvature of the hair through small samples (~3 mm) placed in a petri dish containing isopropanol alcohol (IPA)

Dealing with curly hair and its patterns requires accurate data on hair characteristics such as hair curvature, hair diameter. This paper provides a scientific basis for collecting and analysing this data, which facilitates the training of AI models.

And the Reimagining Hair Science paper presents new standards for curly hair classification through geometric measurements. This paper supports this idea by providing a standardised measurement tool for these criteria.

Paper 5: Deep Hair Phenomics: Implications in Endocrinology, Development, and Aging

This paper presents a tool based on AI and computer vision to accurately measure and analyse hair characteristics to understand the changes that occur in hair throughout age, and the impact of hormones and genetic factors on hair follicles.

Traditional methods such as trichoscopy are effective in assessing scalp health, but they do not give a complete analysis of the hair because it is difficult to measure a large number of hairs due to their overlapping, in addition to the difference in the direction of their growth and angles. So the researchers aimed in this paper to find a high-throughput method to measure an individual's hair in detail, instead of the traditional slow methods, to help in analyzing hair characteristics such as length, width, and colour, this study was interested in how these characteristics are affected by factors such as hormones, genetic modifications, ageing, and hair diseases.

The researchers developed a computer vision methodology that recognises overlapping hairs and measures them from images directly without the need to separate them manually, and performed a parallel treatment of several areas of a single image using a Sliding Window. In this study, samples taken from mice of different ages (from 21 days to 1.5 years) were collected, and the hair was cut from specific areas in the body of the mouse and saved for imaging. After that, the images were divided into 1024×1024 pixels to facilitate processing and reduce the computer load. The OBBDetection model was used to detect hairs and define their boundaries, and the ResNet152 model was trained to recognise hair types with an accuracy of 96.9%.

As a result, they compared a hair classification (specific to humans) made manually and the classification using the tool in terms of length and percentage of each hair type and quantitative measurements such as area, circumference, colour (RGB), and the percentage of dark colour., the results showed that the classification and measurements resulting from the tool are highly compatible with the manual results. Finally, this study proves that the quantitative analysis of hair types gives strong indicators to understand hair development with age or health conditions, and explained how temporal changes in hair characteristics can be tracked under the influence of biological factors (maturity, hormones), which opens

the way to study the effect of age or health status on the pattern of curly hair, orientation and colour spectroscopy can be used to detect the chemical effect of products on colour and shine in curly hair.

Paper 6: KEBOT: An Artificial Intelligence Based Comprehensive Analysis System for FUE Based Hair Transplantation

This paper introduces the KEBOT system, which utilizes the artificial intelligence to accurately analyze hair before and after hair transplantation procedures, and provide surgeons with accurate reports to help in evaluating the procedure. The system consists of:

- A 6-axis robot that moves around the patient's head.
- A depth camera that generates a 3D model of the head.
- A high-resolution RGB camera with a telecentric lens.
- A dedicated light source to optimize the captured images.
- A processing unit.
- Artificial intelligence algorithms.

It aims to detect the number and location of follicles, calculate the number of hairs within each follicle, measure the diameter of each hair (in microns), calculate the hair coverage index, and generate visual and analytical reports for the physician.

The error rate of this system was measured to be less than 5% in most cases, and the results were very close to microscopic measurements.

What makes this study special is its use of advanced technologies such as YOLO, RetinaNet, and SegNet, its comprehensive coverage of all stages of transplantation (before and after), its combination of robotics and artificial intelligence, and providing accurate digital analysis to support the physician's decision.

However, its weakness is that it is designed for specific cases (men with AGA only), and does not cover different hair types or non-medical conditions. In addition, it is not intended for the end user, but rather for the physician only and there is no customization based on hair type or product.

Paper 7: Scalp Diagnostic System With Label-Free Segmentation and Training-Free Image Translation

Scalp diseases and baldness (Alopecia) in particular are diseases that have affected millions of people around the world, which prompted researchers in this paper to research these diseases and how to deal with them. This paper explains that there is no comprehensive system built with Artificial Intelligence (AI) that combines the diagnosis of scalp diseases and baldness due to data imbalance, in addition to the fact that the cost of developing Labels is very high because it needs specialists. Therefore, they presented a solution for a comprehensive diagnosis system based on AI that depends on the division of hair without stickers (Label-Free Segmentation), generating artificial images of rare cases (Diffuse IT-M), also extracting the features of hair (number, thickness) to assess the severity of baldness.

In this paper, the researchers used a specialised database from AL-Hub containing four levels of severity (Good, Mild, Moderate, Severe), 6 scalp diseases such as Dandruff, Sebum, Erythema, Hair loss, baldness

(Alopecia), and others, and about 24,000 images for baldness cases only. They suggested a diagnostic system (ScalpVision) based on two main indicators:

1. Hair Thickness – Hair Thickness.
2. Hair Count – Number of hairs.

To obtain the number and thickness of hairs as indicators of baldness.

And three basic steps:

1. Hair Segmentation Module, where the hair is divided from microscopic images.
2. Data Augmentation by converting images to a specific pathological condition via Image-to-Image Translation while maintaining hair details, in addition to generating images to expand the training data and improve classification accuracy
3. Classification & Severity Prediction, where scalp diseases are classified and the severity of baldness is estimated.

Therefore, the idea of Hair Thickness and Hair Count can be applied to curly hair to determine the pattern or thickness of the hair, and Image-to-Image Translation may be used to simulate different cases of hair conditions, such as wet, dry, conditioned with certain products and their response to them, and thence train an intelligent recommendation system

Paper 8: Hairmony: Fairness-aware hairstyle classification

This paper presents a new hairstyle classification (Hairstyle Taxonomy) developed in collaboration with hairdressers, anthropologists, and technicians using frequent reviews with 30 evaluators from different backgrounds, and has been repeatedly improved based on experiences and studies.

The presented classification system is based on computer vision and deep learning that predicts the person's hairstyle from a single image using clear characteristics across different hair types, the current systems either classify hair directly or by parametric modelling, these methods may be accurate for straight or wavy hair, but they are still weak in representing complex hair patterns such as curly or gathered hairstyles such as cake or horsetail styles. This classification system contains 18 basic properties that describe the shape of the hair as a whole and divides the scalp into 8 regions, each region is characterised by distinctive characteristics such as tuft length, density, style type, and each hairstyle has 74 labels based on these characteristics.

The study was based on two types of data, industrial data generated from the Wood et al library. 2021 In addition to the FairFace Dataset, with images cut to be clear to hair, these images have been carefully selected to include different hair lengths and types, lighting angles and various positions, and proposed a visual classification (Graphical overview) of hairstyles divided into global attributes such as baby hair, hairline visibility, etc and regional attributes such as thickness, hair type, etc.

This paper reinforces the idea that the exact classification of curly hair patterns is essential before any recommendation of products, with a challenge that must be taken into consideration while analysing images, which is the difficulty of recognising hair in poor lighting or complex backgrounds.

Paper 9: Neural Strands: Learning Hair Geometry and Appearance from Multi-View Images

This paper presents a new method for representing and generating 3D hair strands from multi-view images in a geometrically accurate, realistic, and easily modifiable way.

Previous papers have focused on recognizing hair type from static images, while the “Neural Strands model” emerges as an advanced analytical tool that enables accurate reconstruction of the full hair shape from multi-view images. This opens the door to artificial intelligence applications. The Neural Strands model not only recognizes individual hair, but also restores the full shape of the strands, even from different angles, and this is important for hair care applications because it actually analyzes the shape of each strand, its curvature, density, and growth direction. The model develops a system for generating realistic 3D hair strands from multi-angle images, using texture maps representing the shape and appearance of each strand. They use UNET (a U-shaped encoder-decoder network architecture) to generate a realistic final image (RGB + alpha). It was trained on real images, and two types of losses are used:

- A geometric loss to approximate the hair shape.
- A visual loss (rendering loss) to approximate the final appearance with real images.

This paper is considered as the first learning framework that combines hair shape and realistic appearance from multi-angle images, and it is usable in real time for generating realistic images of human hair.

Paper 10: DiffLocks: Generating 3D Hair from a Single Image using Diffusion Models

This paper aims to rebuild 3D hair geometry from a single image using diffusion models which is a serious technical challenge especially for curly or complex hair, such as Afro hairstyles, due to the wide variety of shapes and the lack of realistic data.

The researchers proposed a new framework called DiffLocks to solve two main problems:

- Lack of realistic 3D data.
- Reconstruction of the fine details of each hair.

They created a massive database containing 40,000 (40 K) realistic and diverse 3D hair styles, which now serves as a reference for other researchers. The researchers used Blender to create 3D hair strands, and they trained their model using DINOv2 features to guide the generation process, giving the model the ability to understand the fine spatial details of each hair strand. The model requires no post-processing or additional random strand injections, but rather automatically generates hair containing fine details such as flyaway strands. It is worth mentioning that the model was trained only on synthetic data, yet it successfully generalized to real images.

The DiffLocks paper doesn't focus on product recommendations, but it does offer the ability to generate accurate curly hair images that can be used in model training.

Critical Analysis:

By reviewing previous papers, we can see it is clear that the field of artificial intelligence use in hair analysis is still under development. And most previous studies have focused on specific aspects, such as geometric classification, 3D reconstruction, or studying its physical properties. Even with this progress in technology, clear gaps remain. The main gaps are the lack of a comprehensive approach that integrates curly hair analysis, accurately identifying its pattern, and providing personalized recommendations. Furthermore, most previous models were not built on everyday user data such as mobile phone images, which limits their practical application. Thus, I can say that these studies serve as the foundation building blocks for developing an AI model that accurately analyzes curly hair based on images, classifies it, and provides personalized care recommendations.

Connections:

1. development from Manual Classification to Artificial Intelligence:
Most of papers demonstrate the evolution of hair problems to interpret its properties, whether for classification, generating its 3D shape, or understanding the geometric structure, from relying on human visual analysis (LOIS System and FIA System) to using AI and deep learning algorithms (such as diffusion models, and neural networks). This development illustrates how studies began with traditional methods before adopting modern techniques to improve accuracy and specificity.
2. Reliance on images as the primary source of analysis:
All studies relied on images (either single images or multi-angle images) as a starting point to extract information about hair pattern, this emphasizes the importance of the image as a primary input for analysis.
3. Variety of technical approaches to achieve the same goal:
Tools varied between diffusion models, convolutional networks (CNNs), classification algorithms, and manual techniques, although the overall goal remained within the scope of understanding the hair types.
4. Limited practical usability of some models:
Some models require multi-angle images or industrial data, making them difficult to implement for everyday users, especially in personal applications.

Conflicts between the findings:

1. **Hair Classification: Manual or Automated?**

The “Artificial Intelligence in Hair Research“ paper relies on manual visual classification, and assumes that humans are capable of accurate visual determination without the aid of machine learning algorithms or network models, while the remaining papers rely on automated classification using techniques and machine learning algorithms.

2. **Is the goal classification or recommendation?**

The papers “Reimagining Hair Science” and “Artificial Intelligence in hair research” focus on accurate hair classification.

While “DiffLocks” and “KEBOT” papers focus on advanced analysis (a medical and 3D), but without any connection to user behavior or hair care routines.

Some research suggests that understanding hair patterns is sufficient, while my research demonstrates that this is insufficient without practical steps to help the end user.

3. **Is synthetic data effective?**

Towards Creation of a Curl Pattern System” encountered data quality issues and noted limited image diversity. While “DiffLocks” uses massive synthetic data (approximately 40K images) and has proven effective in training model.

4. **Can AI handle curly hair?**

Some studies such as “DiffLocks”, have successfully demonstrated that AI can analyze and generate very realistic curls. While other studies consider curly hair a challenge that AI cannot overcome.

5. **Should we treat hair as an indicator of measurement and analysis only or as a medical field that needs direct intervention?**

Between the Deep Hair Phenomics paper and the KEBOT paper, we see a clear difference between scientists' view of hair. The first paper sees hair as a health and hormonal indicator (biomarker) that reveals changes in the human body, while the second is seen as a surgical application field (hair transplant using AI).

6. **Label or label free data?**

Labeled data are expensive and difficult to collect, because it needs specialists and doctors. Scalp Diagnostic System paper introduced a label-free method, they developed a self-supervised learning using image translation

Synthesis Matrix for Literature Review:

Study	Authors	Year	Research Design	Key Findings/Results	Methodology	Limitations
Towards creation of a curl pattern recognition system	Hill Kymberlee, Abimbola Adesola, Dangal Prajjwhal, Washington Gloria, III Burge Legand	2018	Proof of concept study	They successfully developed a prototype for hair curl pattern classification using AI techniques and used well-known classifiers systems (Andre Walker, LOIS, FIA) and were also able to analyze images and extract features associated with hair pattern with good accuracy.	They collected images of several curly hair types and used OpenCV to convert the images to grayscale and then binary. They built a CNN to analyze the images and then classified the results according to well-known classification systems.	The database size was limited. And there was no actual user testing.

KEBOT: An Artificial Intelligence Based Comprehensive Analysis System for FUE Based Hair Transplantation	Mohammad Ikram, Imran Sarwar Bajwa, Nazeeruddin in Mohammad, Faisal Baig	2021	Applied System Design	A comprehensive system called KEBOT, based on artificial intelligence techniques, was developed to analyze and process hair transplant cases. The model contributed to improving diagnostic accuracy and customizing treatment plans.	Collecting and analyzing scalp images. Using convolutional neural networks (CNNs) to detect suitable areas for transplantation.	There is insufficient information about user interaction or actual user experience. The system does not include post-transplant recommendations or analysis of hair characteristics such as softness or curl.
Neural Strands Learning Hair Geometry and Appearance from Multi-view Images	Radu Alexandru Rosu, Shunsuke Saito, Ziyang Wang, Chenglei Wu, Sven Behnke, and Giljoo Nam	2022	Deep Learning	The model learns from images taken from multiple angles, reconstructing a 3D representation of hair that closely resembles the real thing.	Combine data from different angles to create a complete representation of hair strands. Use custom functions to adjust appearance, curl, and bend.	It requires multiple angles of the same person, limiting its practical application in everyday life. It does not provide accurate hair type classification.
Artificial Intelligence in hair research: A proof-of-concept study on evaluating hair assembly features	Gabriela Daniels, Slobodanka Tamburic, Sergio Benini, Jane Randall, Tracey Sanderson, Mattia	2021	Proof of Concept Study, Machine Learning	The results demonstrated the AI's ability to distinguish between different types of assembly and morphological characteristics, and the algorithms proved effective in visually classifying hair patterns and characteristics	Collecting hair samples from volunteers.	The study did not rely on a large or diverse dataset, but was limited to the samples collected. The system also does not provide product recommendations or direct interaction with the end user.

	Savardi			without human intervention.		
Reimagining Hair Science: A New Approach to Classify Curly Hair Phenotypes via New Quantitative Geometrical & Structural Mechanical Parameters	Michelle E. B. Joly, Audrey R. Miller, Jena A. Shaw, Patricia A. Turner, Crystal M. Morrison, Michelle A. Gaines	2022	Experimental	A new classification of curly hair has been proposed based on geometric characteristics such as angle, curvature, and length, going beyond the traditional method of relying solely on appearance.	Collect hair samples from volunteers. Develop clear quantitative criteria for classifying hair patterns.	The experiment was conducted on limited samples.
DiffLocks: Generating 3D Hair from a Single Image using Diffusion Models	Huiwen Chang, Xiaohui Zeng, Hanbyul Joo, Jingwan Lu, Xiaohui Shen, Jimei Yang	2023	Deep Learning and Diffusion Model-based Design	The model produces consistent geometric properties of hair, delivering high-quality results that can be animated and integrated into 3D environments. The model outperforms previous methods in terms of accuracy and realistic appearance.	Using a Diffusion Model. Train the model on data containing 2D images and their corresponding 3D images.	There is no built-in mechanism for automatically identifying hair type or pattern (classification).
Scalp Diagnostic System With Label-Free Segmentation and Training-Free Approach	Youngmin Kim, Saejin Kim, Hoyeon Moon, Youngjae Yu, Junhyug Noh	2024	Applied research and analysis using label-free segmentation and training-free frameworks.	Proposed an AI-driven diagnostic system capable of segmenting hair and scalp without manual labels or extensive training data. Demonstrated efficiency in identifying scalp conditions with reduced data requirements.	Developed label-free segmentation techniques leveraging pseudo-label generation and training-free architecture s.	Performance may degrade on rare or complex scalp conditions. Limited generalizability without larger, more diverse datasets.

High-throughput phenotyping methods for quantifying hair fiber morphology	Tina Lasisi, Arslan A. Zaidi, Timothy H. Webster, Nicholas B. Stephens, Kendall Rutch, Nina G. Jablonski, Mark D. Shriver	2021	Methodological research	Introduced scalable, quantitative methods to analyze hair fiber morphology including curl, diameter, and cross-sectional shape. Enabled large-scale phenotypic studies and deeper understanding of genetic and environmental influences on hair traits.	Developed imaging-based and computational pipelines for hair fiber analysis. High-throughput quantification included geometric and structural measurements of hair fibers.	May miss microstructural biochemical properties. Focuses more on morphological features than biochemical or health-related ones.
Deep Hair Phenomics: Implications in Endocrinology, Development, and Aging	Jasson Makkar, Jorge Flores, Mason Matich, Tommy T. Duong, Sean M. Thompson, Yiqing Du, Isabelle Busch, Quan M. Phan, Qing Wang, Kristen Delevich, Liam Broughton-Neiswander, Iwona M. Driskell, و	2025	Exploratory and analytical research	Hair phenomics provides insights into developmental and endocrine changes across lifespan. Deep learning models capture correlations between hair morphology and hormonal/aging markers. Highlights hair as a non-invasive biomarker for systemic health.	Integrated high-throughput hair phenotyping, endocrinological assays, and AI-driven pattern recognition. Applied computational models to link hair fiber morphology with hormonal and age-related variables.	Requires large-scale datasets combining medical and phenotypic information.

	Ryan R. Driskell.					
Hairmony: Fairness-aware hairstyle classification	Meishvili, G., Clemoes, J., Hewitt, C., Hosenie, Z., Xiao, X., De La Gorce, M., Takacs, T., Baltrusaitis, T., Criminisi, A., McRae, C., Jablonski, N., Wilczkowiak, M.	2024	Development of a fairness-aware hairstyle classification system using a novel hairstyle taxonomy, synthetic + real datasets, and DINOv2 backbone CNN.	The model achieved high accuracy and fairness across diverse hairstyles, especially frizzy, curly, and gathered hair types. It outperformed traditional parametric approaches by using a taxonomy-based classification that reduces bias and improves generalization.	Introduced a new hairstyle taxonomy with 74 attributes; used synthetic hairstyle dataset and FairFace real dataset; trained CNN (DINOv2) with attribute and style prediction heads; evaluated fairness and accuracy across demographic groups.	Some failure cases in detecting short, frizzy, and medium-length gathered hair due to lack of visual cues at the back of the head.

Research Methodology

This research adopts an experimental design approach based on AI and machine learning to comprehensively analyze the existing challenges and solutions related to curly hair. This methodology is chosen due to the nature of curly hair requires practical experiments, the experimental design approach is flexible and allows us to modify inputs and measuring results

Phase 1: Literature Review

The phase involves an extensive literature review to identify and synthesize existing research on Curly Hair in the field of AI. This review covers scholarly articles, conference papers, industry reports, and relevant legal and ethical guidelines. The purpose is to map out the current landscape of curly hair in the field of AI

Data Sources: Academic databases (e.g., IEEE Xplore, PubMed, ACM Digital Library) and professional publications.

Selection Criteria: Publications from the last ten years, focusing on hair analysis and image processing and analysis

Analysis Technique: Thematic analysis to identify recurring themes, challenges, and solutions.

Phase 2: Data Collection & Preprocessing

The phase involves collecting images of different hair types, especially curly hair, and data on the ingredients of hair products approved by the Curly Girl Method. After this, the data will be pre-processed by adjusting the lighting and colours of the images to be clear, and standardising the size of the images (resize images), then hair segmentation where the hair itself will be identified and separated from the rest of the elements of the image such as the face or background so that the model focuses on the hair only. At this stage as well, the properties of the hair can be extracted geometrically (feature extraction), like curvature, thickness, and strand shape

Phase 3: Model Development & Training

The phase involves choosing appropriate algorithms to work with. A CNN (Convolutional Neural Network) will be chosen because it is suitable for dealing with images that contain curves and shapes, in addition to Transformers (Vision Transformer - ViT) for their strength in understanding complex patterns. After that, the data will be prepared and the model will be trained on it.

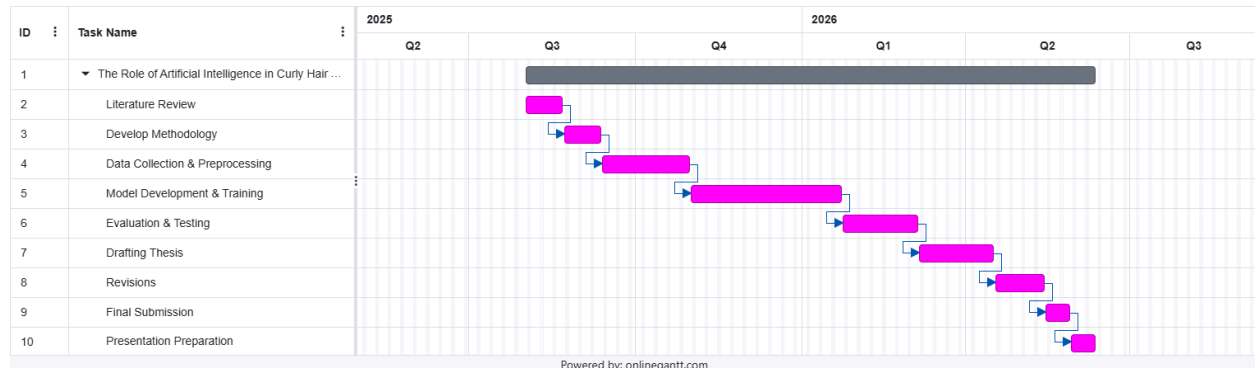
Phase 4: Evaluation & Testing

After the model is developed and trained, a test must be conducted to make sure that the model works correctly as expected. A testing data set will be used, then a performance will be measured (Evaluation Metrics) to measure model accuracy, strengths and weaknesses

Expected Outcomes:

- Higher accuracy in curly hair classification compared to traditional methods.
- A system capable of recommending suitable products according to the ingredients of the product and the type of hair.

Gantt chart:



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