

# Towards Creation of a Curl Pattern Recognition System

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**Abstract**—This work describes different hair typing systems and proposes a recognition system that can be used to classify human hair curl pattern. The Andre Walker hair typing system is used as a basis for defining curl type. Curl type is a term used to describe how curly, wavy, or kinky a person's hair is according to 4 categories. This work limits recognition of curl types to categories 4a, 4b, 4c, and 3c. The hair analysis algorithm described in this work was initially developed as a pilot project through studying approximately 30 subjects that provided pictures of their hair. In this work, we describe a classifier that labels hair images and will eventually lead to a system for recognizing an individual's curl pattern. Results from this work may lead to technologies to suggest hair care products for persons with textured hair.

**Keywords**—hair analysis, convolutional neural networks, image recognition, curl pattern recognition

## I. INTRODUCTION

The average number of hair strands on a person's head is close to 100,000 [1]. Thus, hair seems densely packed on the scalp. Hair classification is a complex pattern recognition problem because traditional computer vision techniques like object segmentation or image recognition are hard to apply directly.

The three-dimensional shape of hair fiber varies considerably depending on a person's ethnicity and geography, with examples from very straight hair with no curve, to the tightly sprung coils of the black race [5]. Few researchers in computer vision and pattern recognition have studied use of human hair shape characteristics [2, 3]. Some researchers have focused on hairline and color with average results. Identifying curl pattern can give more information about a person's identity, hair texture, and hair porosity.

Many women and men with textured hair struggle with finding hair products that cater to their hair care needs. Because of this, this research was started to study how to create computer vision algorithms that can start to recognize individual curl patterns common in human hair.

This paper will describe the three major hair classification systems, why they exist, and how hair features like curls and hair strand type can be used as a basis to classify hair. Finally, the paper discusses an approach to classify human hair into types suggested by the Andre Walker typing system. This methodology will be used to create a hair curl recognition system. The proposed system described in this

paper may be used to produce software that recommends products to individuals with textured hair.

## II. HAIR TYPING SYSTEMS

### A. Andre Walker Hair Typing

The Andre Walker hair typing system is the most widespread system that has been accepted by consumers and cosmetologists. This system divides hair into 4 types – Type 1, Type 2, Type 3 and Type 4.

#### Type 1

Type 1 hair is straight; however, Andre categorizes this hair type into three very specific segments - 1A, 1B, and 1C. Type 1A hair is described as fine, very thin and soft with a noticeable shine. Type 1B hair is medium-textured and has more body than Type 1A hair. Type 1C hair is the most resistant to curly styling and relatively coarse compared to other Type 1 hair types. Figure 1 shows the follicle shape for type 1 hair.



Figure 1

#### Type 2

Type 2 is wavy hair that usually isn't overly oily or very dry. Andre Walker specified that Type 2 hair falls in between Type 1 and Type 3. Type 2A hair is fine and thin. It is relatively easy to handle from a styling perspective because it can easily be straightened or curled, according to the Curl Centric website. Type 2B hair characteristically has waves that tend to adhere to the shape of your head. Type 2C hair will frizz easily and it is fairly coarse. Curly hair textures have a definite "S" shaped curl pattern. Since the cuticle doesn't lay

flat, curly hair isn't nearly as shiny as Type 1 (straight hair) or Type 2 (wavy hair) hair types. Figure 2 shows the follicle shape for type 2 hair.

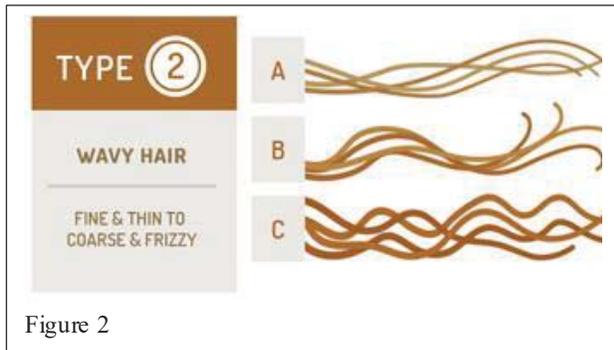


Figure 2

### Type 3

Type 3A hair is very shiny and loose. Type 3B hair has a medium amount curls, ranging from bouncy ringlets (spiral like curls of hair) to tight corkscrews (spiral-shaped corkscrew curls). Type 3C hair isn't a part of the Andre Walker Hair Typing System. Figure 3 shows the follicle shape for type 3 hair.



Figure 3

### Type 4

Type 4 is "kinky" or more appropriately full of tight coils (tightly curled hair). Typically, Type 4 hair is also extremely wiry and fragile. Often times, it appears to be coarse, however, it is really very fine, with several thin hair strands densely packed together. Type 4A hair is full of tight coils. It has an "S" pattern when stretched, much like Type 3 curly hair. Type 4B hair has a less defined pattern of curls and looks more like a "Z" as the hair bends with very sharp angles. Type 4C hair isn't a part of the Andre Walker Hair Typing System. I think it's fair to say that Andre Walker's hair typing system was meant to simplify a very complex process. His deliberate lack of detail in the descriptions of hair types allows them to be more inclusive than exclusive. Figure 4 shows the follicle shape for type 4 hair.

### B. LOIS Hair Typing

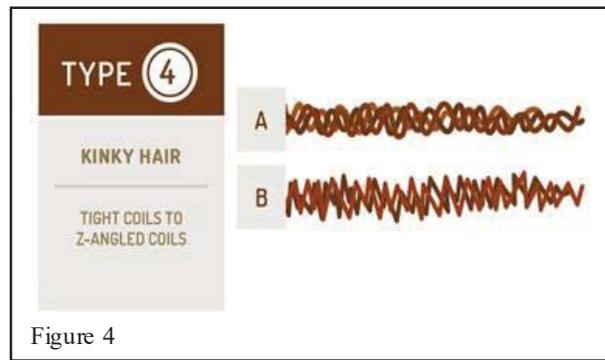


Figure 4

The LOIS Hair Typing system is less widely known than the Andre Walker Hair Typing System. Created by the former website OurHair.net, The LOIS system is aimed at defining hair away from a number and more into a description of the strand shape, size and sheen. It defines hair using three characteristics: pattern, strand size, and texture. The hair pattern is defined by the letters LOIS. If hair is dominated by right angles and substantially bends with nearly no curve, then it is considered a pattern "L". If hair strand curls or coils significantly and appears to be shaped like the letter "O", then it is considered a pattern "O". If hair has no distinctive curls or bends and primarily lies flat against your head, then it is considered a pattern "I". If hair strand has "S" shaped curls or waves with defined hills and valleys, then it is considered a pattern "S". (Here et al., 2018) A head of hair may have several different LOIS hair patterns. When this occurs, the system allows you to combine LOIS letters to determine the hair pattern. For example, the hair pattern may be an "OS" LOIS hair type. In this example, the hair would contain primarily a combination of "O" shaped spiral curls and "S" shaped curly waves with defined hills and valleys. Identifying hair strands within the LOIS system starts with using a strand of frayed thread. One piece of a frayed thread (like a piece of sewing thread) is used as a proxy to determine the size of hair strand. The general thought is that a piece of thread is approximately the size of a medium sized strand of hair. Examining a representative strand of hair, will show if it is thin, average or thick hair. It is common to confuse thickness of hair with density. Density is how closely placed together hair strands are as they grow out of the scalp. If your hair looks thinner than the piece of thread, you have thin hair. If it's thicker, obviously you have thick hair.

### C. FIA Hair Typing

The FIA Hair Typing System appears to expand on Andre Walker's Hair Typing System and also incorporates components of the LOIS Hair Typing System. The system defines hair using three classifiers: the definition of your curls (think Andre Walker), the appearance of most of your hair strands, and the overall volume of your hair. The first classifier defines hair type by determining the curliness of the hair strands is analogous to Andre Walker's system utilizing Type 1 – straight hair, Type 2 – wavy hair, Type 3 – curly hair and Type 4 – really curly hair. The second classifier focuses on the appearance of the majority of the hair strands. Actually, this classifier is very similar to the hair strand sizes used within the LOIS system, but there are some minor differences in terminology. Fine hair is defined as thin hair strands that feels

almost like an ultra-fine strand of silk. Medium sized hair strands, which generally feel like rolling a cotton thread between your thumb and index fingers, are ones that simply fall in between the fine and coarse categories. Coarse hair are thick hair strands that feel hard and wiry. The third classification of FIA's Hair Typing System measures the overall volume of the hair. Simply place the hair in a ponytail. As much hair as possible must fit in the ponytail. There is no need to worry too much about how the hair looks, because the goal is to have the majority of your hair included in the ponytail. Once you have the majority of your hair in a ponytail, the next step is to measure the circumference of the ponytail. A soft tape measure or another method that won't damage the hair to measure the circumference of the ponytail below the elastic used to hold the ponytail together. The number shown on the soft tape measure is used to determine whether the hair fits into the thin, normal or thick according to FIA's Hair Typing System. If the circumference of the ponytail is less than 2 inches (less than 5 centimeters) then it will be considered thin. If the circumference of the ponytail is between 2 – 4 inches (between 5-10 centimeters) then it will be considered normal. If the circumference of the ponytail is greater than 4 inches (greater than 10 centimeters) then it is considered thick. The FIA system takes a few more hair characteristics into account for a better overall hair type diagnosis.

### III. METHODOLOGY

#### A. Curl Identification Pre Processing

Before beginning the project, a web scraper was built to harvest images from the web that fit into the 4c, 4b, 4a, 3c, 3b, and 3a categories. Because each tool needs to train on many images, upwards of 500 images were collected for each category.

An image file is first converted to grayscale and histogram analysis is performed for normalization of the image. The grayscale images are converted into binary image. Using active shape models we perform feature extraction and use this as input into deep learning software to determine curl type. The binary images are then resized into 30 x 30 pixels as the starting dimension specification for a convolutional neural network. Figure 5 and Figure 6 show binary images and contours on binary images respectively. The images below are for representation purposes only, as the proposed system will require the images be pre-segmented eliminating any non-hair part of the image. This will ensure our algorithms only trains on relevant hair structures.

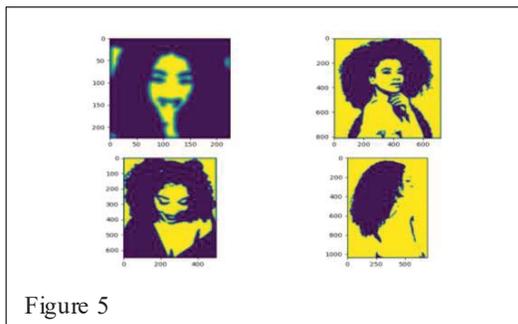


Figure 5

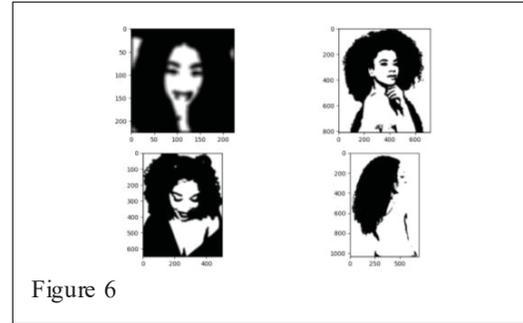


Figure 6

#### B. Curl Classification

Our technique can be described in two steps:

1. Curl Identification using Active Shape Models and deep learning software
2. Recommendation of products based on the previous two steps.

OpenCV Haar Cascade tool and Tensor Flow deep learning software is used to detect, segment, and classify the four categories of hair types explored in this work: 4a, 4b, 4c, and 3c. These tools were chosen because they have been used by other researchers in computer vision to build object detectors relatively simply and there is ample documentation on how to use them for student research projects. Example images for each curl type is provided to both the OpenCV Haar Cascade tool and the TensorFlow Deep learning software

In order to build a system robust enough to recognize different curl types from one individual's head, it is necessary to build a classifier for using the Andre Walker curl typing system as the basis for identifying images metatagged with either 4a, 4b, 4c, or 3c. A web scraper tool was used to pull representative images from the Internet for building the classifier. Next, the image dataset resulting from the web scraper was analyzed to perform quality assurance of the images contained in the repository. Note, the web scraper tool was only used to find an ample training set for building the classifier.

In addition to data collected from the web, we gathered participant data from 30 subjects. Figure 7 shows a breakdown of the hair curl types gathered from the volunteers.

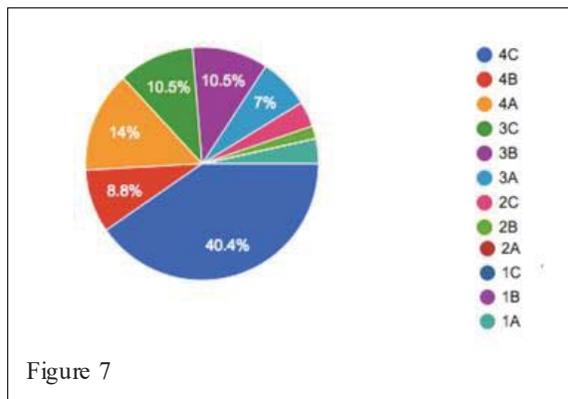


Figure 7

DISCUSSION

This approach for developing a classifier has only been trained for textured hair (3a and above using the Andre Walker classification system). However, it could be retrained and tested for non-textured or straight hair in the future. This work was developed for textured hair because we believe it is a more difficult computer vision problem to tackle and results from this work could prove more useful to a wider segment of society.

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