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Identifying hair traits in a facial image

ACM Classification:

I. Computing Methodologies

    I.4 IMAGE PROCESSING AND COMPUTER VISION

        I.4.6 Segmentation

            Edge and feature detection

MSC Classification:

68-XX COMPUTER SCIENCE

68Txx Artificial intelligence

    68T45 Machine vision and scene understanding

Laborator 5-8

2. Related Work

The problem of hair segmentation, as well as of classifying specific traits, has been approached before, from various perspectives and using different implementations.

In [1], the focus is, as the title suggests, on hair segmentation and color classification, from a visagisme perspective. In this approach, the segmentation and classification are done on facial images, face detection playing an important role in identifying the hair region. For the segmentation problem, a U-Net fully convolutional network with two symmetric parts is used. In the first part, represented by the contraction path, the image is down-sampled, using depth-wise convolutions. In the second part, respectively the expansive path, the down-sampling operations are reverted by using transpose layers. A flood-fill algorithm is later used to complete the gaps in the detected hair mask, and an algorithm based on detecting the face outline determines whether the subject is bald or not. For the hair color classification part, a normalized color histogram is fed into a classical ANN, using the RGB, HSV and Lab representations.

S Sarraf focuses, in [2], on the idea that detection of the hair region is of significant importance in automatic human identification for security reasons. Unlike the previously described work, the current paper classifies detected hair into black or non-black. Low-level features (R, G, B, H, S, V) were extracted, a vector normalization was performed and then fed into two types of classifiers: SVM and K-NN. Both had good results on the larger database (460 images), but worse performance on the smaller database (200 images).

An issue that has occurred when trying to solve hair segmentation and classification problems is the relatively limited number of images available in datasets ready to be used. This issue is mentioned or can be noticed in the papers above as well, as the authors had to annotate images themselves or used a relatively small dataset. [3] describes the creation of a large dataset designed specifically for this type of work. For creating the dataset, both an auto-labelling model and humans were used. The resulting masks were used in three types of hair manipulation applications. For hair dyeing, the segmentation masks needed to be predicted corresponding to hair regions. U-Net, Feature Pyramid

Network, Pyramid Scene Parsing Network, DeepLabv3+ and Pyramid Attention Network are used for segmentation, and after comparing the results, PAN seems to be producing the most reliable results. K-nearest-neighbor matting and alpha matting are further used to produce accurate segmentation masks. The color is finally changed in a realistic manner by modifying HSV instead of RGB. For hairstyle transfer, a reference-based image-to-image transfer model, StarGAN v2 [5], is used, managing to transfer the hairstyle even when the position or gender of the target subject differs from that of the reference model. For hairstyle classification, ResNet101 [4] produces the best results.

These papers tackle the problem of hair classification from various perspectives, as they have different purposes. The idea of the current research is to try these approaches on a similar, yet different problem, of classifying hair into 12 types based on the curl pattern. This is challenging because of the similarity among close classes and their overall big amount. This is why very high accuracy when it comes to the exact classification is not expected, but it is hoped that a higher accuracy will be obtained if close classifications (one or two classes apart) are also taken into account.

3. Dataset Collection and Annotation

Since hair related computer vision problems have been studied in the past few years, there exist a few datasets consisting of annotated hair images, but they are not all completely suited for the current problem, since they don't contain the exact curl type annotation. K-Hairstyle [18] and Figaro 1K [19] are datasets containing annotated images of real people, and the former is used for several applications described in [3] and mentioned in the "Related Work" chapter, though it censors faces. Hairstyle 30K [20] is generated by a GAN.

However, for the current research, a custom dataset has been created, taking into account the 12 curl types. Most pictures were taken from the Internet, some from the other datasets, and all have been manually annotated to correspond to a class. Variety regarding gender, skin colour, race, hair colour and hair length has been taken into account in order to avoid biased results because of an unbalanced dataset.

4. Proposed Solution

The aim of this paper is to find the most accurate method of classifying hair curl types according to the 12 labels detailed in the table below, from 1A to 4C. It is important to notice that even for the human eye, it is sometimes hard to differentiate among types that are one after another. Thus, the strict classification is not the only one that we follow to evaluate, but we are also interested in how close the prediction label is to the actual label.

	A	B	C
1 (straight)	Fine, straight hair	Thicker straight hair	Coarse straight hair
2 (wavy)	Fine, S-shaped curls	Looser curl, still S-shaped	Loose curl
3 (curly)	Shiny, defined curls	Combination of curls and coils	Combination of defined coils
4 (coily)	Soft, well-defined coils	Shiny, less defined coils	Sensitive, undefined coils

4.1. Metrics

We are interested in the accuracy of the classification, i.e.

accuracy = (TP + TN) / (TP + TN + FP + FN),

where TP = true positive, TN = true negative, FP = false positive, FN = false negative.

4.2. Case Study - Experiments

1. A CNN is the first experiment used for this classifying problem, with the aid of the Tensorflow Keras model.

    a. The first configuration has 10 layers, including 5 Conv2D layers, 2 Add layers, one Global Average Pooling 2D layer and a Dense layer. As an optimizer, Adam is used, and since it is a classification problem, we use SparseCategoricalCrossentropy as the loss function. The noticed results using 32 batches is unsatisfactory, with an accuracy of 0.12 after 20 epochs.

    b. Another tried configuration is MaxPooling2D and Dense layers as well, and it produces slightly better results faster, respectively an accuracy of 0.1425 after the 2nd epoch, until which it drops again.

2. In [3], the most efficient approach for hairstyle classification was using a ResNet101. Indeed, using a pre-trained model has been observed to perform well on smaller datasets. This is reflected in the current case as well, since in a dataset with 12 classes and approximately 50 input pictures/class, ResNet101 achieves an accuracy of 0.84 after only 10 epochs, an actually good accuracy, especially compared to the above-mentioned approach.

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Related Datasets:

18. K-Hairstyle: A Large-scale Korean Hairstyle Dataset for Virtual Hair Editing and Hairstyle Classification https://paperswithcode.com/dataset/k-hairstyle

19. Figaro 1K http://projects.i-ctm.eu/it/progetto/figaro-1k

20. Hairstyle 30K https://yanweifu.github.io/papers/hairstyle_v_14_weidong.pdf