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RESEARCH PAPER

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AYURVEDIC DOSHAS IDENTIFICATION USING FACE AND BODY IMAGE FEATURES

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Abstract: Ayurveda is an alternative medicine system with historical roots in India. In Ayurveda, any disease is considered to be caused by the imbalance of various Doshas (Vata, Pitta & Kapha) in human body. In order to diagnose this imbalance of doshas, there are several methods, out of which one is to observe visually the different features of the human body. Body type, skin type, hair type, eyes type, face type, etc possess different characteristics under the influence of various doshas. Hence the idea is to automate this process where we scan a body image using machine learning and deep learning algorithms and classify the different features into different doshas to finally conclude the dominant dosha as result.

Keywords: ayurveda, ayurvedic doshas, dosha identification, ayurvedic diagnosis, vata pitta kapha, machine learning

I. INTRODUCTION

Ayurveda is an ancient science for understanding our body and mind so that we can achieve good health and a long life. In Ayurveda, a body is considered as the combination of five fundamental elements: Earth, Water, Fire, Air and Ether. In order to stay healthy, a proper balance of these five elements is necessary. Further, as our body is a complex system, Ayurveda has classified three different combinations of these elements which represent different functions in our body, they are known as Vata (combination of Ether & Air), Pitta (combination of Water & Fire) and Kapha (combination of Water & Earth). If there is any imbalance of fundamental elements in our body, these combinations will get affected and the affected combination(s) will become dominant. Any dominant combination will hence show its effects by building certain features of the body – physically and behaviorally.

Any disease in our body is understood as an imbalance of these elements in our body, and to diagnose the same we check for these combinations (Vata, Pitta & Kapha), the imbalanced one is known as Dosha while diagnosing. To figure out dominance of these doshas, we have many techniques in Ayurveda like Nadi reading (detailed pulse diagnosis) and Feature reading. Just by looking at someone's physical features of the body or by co-relating their behavioral features, we can identify which dosha(s) is/are dominant in their body. For e.g If a person's body is thin and tall built will low weight, he/she possesses dryness in their biological system and is very fast in his/her activities, it means Vata Dosha is dominant in that person, similarly if someone is heavy in weight, large built with slowness in activities we can say that there is Kapha Dosha dominant in that person.

This classification used to help diagnose many diseases from just the physical appearance of people and hence curing them by correcting their lifestyle and using herbs. In order to preserve this technique, we can take advantage of modern science & technology. With the help of image recognition, we can identify various features of someone's body, tag them with their types and hence figure out which doshas are dominant. This is the fundamental idea of this work.

There are 3 fundamental doshas, Vata, Pitta and Kapha, hence there can be 7 different combinations of doshas which can exist in a body as mentioned in Table 2.1. These variations can be seen expressing more physical characters of the body.

A. Vata Dosha

Properties of Vata dosha are dry, light, mobile, rough, cold and swift nature. A person having this dosha will show these characteristics in physiology, morphology, mental and physical behavior. Vata person is tall and thin with small body frame having long face with sunken cheeks. Their skin shows dryness, roughness and lack of luster. They are intolerant of cold and they are physically weak. They don't have sound sleep and show restless in nature. Their mind is also never steady and they forget things easily. Also, they are talkative and active.

B. Pitta Dosha

Properties of Pitta dosha are hot, sharp and liquid in nature. A person with Pitta dosha will show these characteristics. They are generally medium built with medium height. Their skin is very soft, reddish and shows luster. Their nails, eyes and tongue have coppery red color. Their appetite is high and they have moderate strength and stamina. They cannot tolerate heat and they have sharp

intellectual mind. Also they present clarity of mind and sharp talk.

C. Kapha Dosha

Properties of Kapha are heavy, soft, cold and unctuous. A person with Kapha dosha has these characteristics. They have large body frame and are usually overweight. Their skin is unctuous, soft and moist but also pale and cold. They have big beautiful white eyes and chubby cheeks. Their appetite is low and they show sluggish activities. Their sleep is very long and they speak slowly with a deep voice. They are less active and calm but have good stamina [1].

Type	***Description***
Vata, Pitta, Kapha	Predominant in one Dosha
Vata-Pitta, Vata-Kapha, Pitta-Vata	Two relatively equal proportions with one predominating
Vata-Pitta-Kapha	Doshas in almost equal proportion

The psychosomatic constitution of a body, depending upon the relative predominance of three doshas can be divided into 7 categories, Vata, Pitta, Kapha, Vata-Pitta, Vata-Kapha, Pitta-Kapha and Samdosha as mentioned in Table 1.1. Each of the body feature has certain characteristics, using which we can determine the type of dosha. These characteristics of different body features are shown in Table 1.2. The constitution provides insights into the deeper workings of some individual. With proper identification, it is possible to be aware of the diet, spices, medicines, thoughts, emotions, climates, lifestyles and colors that can lead to balance or imbalance of an individual. Also various diseases can be foretold, diagnosed and prevented by analyzing the constitution. It also helps in determining the progress and effectiveness of therapy for effective treatment.

Table 1.1 Types of Doshas [2]:

Table 1.2 Characteristics of Tridosha [2], [3]:

No.	***Observation***	***Tridosha***		
		Vata	***Pitta***	***Kapha***
1	Body size	Slim	Medium	Large
2	Body weight	Low	Medium	Overweight
3	Cheeks	Wrinkled/sunken	Smooth flat	Rounded, plump
4	Face shape/ chin	Angular, thin	Tapering, triangular	Double chin, rounded
5	Eyes	Black, brown, nervous, small, sunken, dry, active,	Bright, sharp, yellow/red, gray, green, sensitive to light	Beautiful, big, blue, calm, loving
6	Nose	Uneven, deviated septum	Long pointed, red nose-tip	Short rounded, button nose
7	Lips	Dry, cracked, black/brown tinge	Red, inflamed, yellowish	Smooth, oily, cool, white, pale
8	Teeth	Big, roomy, Stick out, thin gums	Soft, medium, tender gums	White, healthy, strong gums
9	Skin	Cold, rough, thin, dry, dark	Oily, warm, smooth, rosy	Oily, cool, thick, white, pale
10	Hair	Knotted, brittle, scarce dry, brown, black	Blonde, gray, red, bald, straight, oily,	Wavy, luxuriant, thick, curly, oily
11	Appetite	Scanty, irregular	Unbearable, strong	Slow and steady
12	Digestion	Forms gas, irregular	Quick, causes burning	Prolonged, forms mucous
13	Thirst	Changeable	Surplus	Sparse
14	Emotions	Anxiety, uncertainty, fear	Hate, anger, jealously	Greedy, calm, attachment
15	Mind	Restless	Impatient	Calm
16	Intellect	Quick with faulty response	Accurate response	Exact and slow
17	Speech	Unclear, talkative, rapid	Sharp, penetrating, clear	Slow, quiet, monotonous
18	Voice	Weak, hoarse	Strong tone	Deep, good tone

As we know that various diseases are caused by the imbalance of doshas and in order to identify the dominant doshas there are mainly 3 different methods [4]:

1. ***Sparsha:*** This is a touch based diagnosis where heart rate and body temperature are analysed by placing fingers around the wrist of an individual.
2. ***Prashna:*** This is a question based diagnosis where an individual is questioned about their lifestyle, sleep-pattern, appetite, levels of energy etc.

3. ***Darshana:*** This is a visual diagnosis which is performed by observing the physical features of an individual's body like body frame's build, height, weight, hair, skin, teeth and eyes.

With evolving Machine learning algorithms and high computational power, image-recognition has evolved a lot. We can extract the facial features and body features for various applications. The same process we will be using for Darshana based Ayurvedic Doshas identification. The results of body type and facial feature types will be combined to calculate the dominating Dosha(s) in an individual.

We will classify the following body features using different algorithms:

A. Body build-type analysis

Using the body image as input, we need to analyze the shape of body and then conclude the build whether it is thin, medium or heavy. As we know from constitution chart that Vata people are thin & tall, Pitta people are medium built and Kapha people are heavy built. There are various algorithms [8] [9] available which we can use and train our model to predict the body build like principal component analysis and k-means for clustering the data and producing results [10].

B. Face shape analysis

Using the face image of an individual as input, we need to analyse the shape of the face. As we know, Vata people have angular face shape with defined cheek bones, Pitta people have pointed chin and Kapha people have rounded face. Active shape model can be used for the classification of face shape. Various geometry shapes like square, ellipse, square, triangle, circle etc are used to calculate similarity with the face using region similarity, fractal dimensions and correlation coefficient [5]. Algorithms detect boundary of the face and in order to classify them in the shapes [6], [7], edge boundaries that are detected using these algorithms can be fed to another model to detect its similarity to a geometrical shape.

C. Skin Analysis

Using the face image as input, we need to extract the skin features like skin color. As we know, Vata people have thin, rough, dry, dark, grayish black, dark brown, Pitta people have smooth, oily, whitish, warm, pinkish, and yellowish and Kapha people have oily, thick, pale, cool, white, wheatish skin characteristics. We can extract the color feature of the skin using the RGB value of the pixels. Various algorithms like multi-layered perceptron, Baayesian classifier with histogram technique, Gaussian classifier and random forest can be used to detect the skin regions in the image. After the detection of skin regions, pixel values of the clusters are evaluated using YCbCr or RGB color space [11], [12].

D. Eyes Analysis

Using the image as input, we need to analyse and extract different features of the eyes like color, eyelids and its geometrical shape, iris, pupil [13]. As we know, Vata people have small, sunken, dry, active, brown or black tones of iris, Pitta people have nervous, sharp, bright, yellow/gray/red-gray/green iris tones, Kapha people have sensitive to light, big, beautiful, calm, loving, blue iris tones of eyes. Deep learning methods can be used to extract the features where we can localize the facial area in the image using Viola-Jones face detector and then segmented using AdaBoost algorithm. We can further extract the eye patches from facial regions using neural network, after which we will use YCbCr or RGB colour space to classify the color or the eye [14], [15].

E. Hair Analysis

Using the image as input, we need to analyse and extract the features of hair. As we know, Vata people have dry, thin, curly, sparse hair and Pitta people have thin, straight, soft, blonde, brownish red, tawny, bald, receding hairline and Kapha people have oily, thick, curly, shiny, black, backish blue hair characteristics. First we will detect the hair and non-hair regions in the image using support vector machines and random forest [16], [17], and then we will label the central pixels where the presence of hair is uncertain [18] and then finally we will classify them in straight/kinky/wavy/curly types using CNN models like VGG-VD, CaffeNet for hair detection [16]. Hair color can be extracted by defining color boundaries using the YCbCr or RGB colour space while segmenting the hair pixels [19].

After classifying the different features of the body into Vata, Pitta and Kapha, we can find out one's effective dosha by adding up the scores of all different features. Whichever dosha will have the highest score, will be the dominant dosha. This way we will be able to conclude the results [3]. Also, it is possible that two or three doshas tie in scores, at that time we will conclude the combination of highest scoring doshas as dominant dosha. Hence the final dosha can be Vata, Pitta, Kapha, Vata-Pitta, Vata-Kapha, Pitta-Kapha, Vata-Pitta-Kapha.

II. METHODS

A. Collecion of Dataset

As we will be using Machine Learning for the doshas identification, we will need some data that we can analyse and train our model to recognize the corresponding dosha on the basis of features in the given image. It is a difficult task as the data is present of all variations including unclear images, different lighting conditions, and people of different race having different kind of features (i.e. facial hair, facial expressions) not necessarily due to dosha.

Not only we need to collect the data but also define and extract the different features like body build type, face shape, eyes color and shape, skin color etc before training our models on it. After that we will be able to categorize different features into their individual dosha type.

For our purpose we collected some pictures manually using internet form and have used Celebrity Face Recognition Dataset [20] as it contains 8 lakh pictures of more than a thousand celebrities. We shortlisted pictures of different celebrities from this dataset based on some parameters like single person image, minimum make-up, decent lighting conditions, high definition quality, without wearing glasses, without visible teeth. Out of these, we labeled around 300 images as Vata, Pitta, Kapha, Vata-Pitta, Pitta-Kapha, Vata-Kapha, Vata-Pitta-Kapha with the help of an experienced Ayurvedic doctor.

For hair texture analysis, we used Figaro1k Dataset [21] which contains thousands of pictures of different hair type with different attributes like straight, braids, dreadlocks, short, wavy, kinky, curly. We shortlisted a subset of around 500 images and manually labeled them into different doshas.

B. Engineering of Features

In order to implement our idea, we need to use the following feature set for analysis:

Table 2.1 Physical feature-set for dosha determination

No.	***Feature***	***Kapha***	***Pitta***	***Vata***
1.	Body build	Heavy	Medium	Thin, Light
2.	Skin colour	Wheatish	Fair	Brown
3.	Hair colour	Black, Brown	Light Brown, Blonde	Gray
4.	Hair Type	Thick, wavy, smooth	Shiny, bald, straight	Dry curly, scarce
5.	Eye colour	Black, Brown	Light Brown, Blue, Green	Gray
6.	Eye size	Large	Medium	Small
7.	Lip colour	Pale Pink	Red, Pink	Brown
8.	Lip size	Large	Medium	Small
9.	Nose size	Large	Medium	Small

We need to extract features mentioned in Table 2.1 and in order to do so, we have followed the below steps:

i. Body build type analysis:

We have used MPII Human Pose Database [22] and shortlisted around 200 images out of thousands, which were relevant for this study. We have used NumPy to input the images.

To predict the human body shape, the principal component analysis (PCA) method is proposed to reduce the associated variables and eliminate heterogeneity between variables. The transformational variables are then integrated into genetic algorithm and BP neural network, and a new method for predicting the shape of the human body is devised.

To avoid problems that slow convergence speed and easy falling into local minima of BP neural network, genetic algorithm is used to optimize the weights and thresholds of the BP neural network. The results show that the prediction of PCA-GA-BP neural network is much better than that of any other algorithm like K-means, to conclude the shape of human body.

Once body shape is clustered into light, medium and heavy, we can conclude the effective dosha for build type as Vata, Pitta and Kapha respectively.

ii. Skin classification:

We need to extract the color of human skin from the given set of images. To do this we will follow three steps as mentioned below:

a. Image input: We have read the images using NumPy array which is present in NumPy library, which uses 3-D matrix for RGB color channels.
b. Setting the threshold: We will create a binary image by removing the pixels that are out of the given range (an upper and lower bound) [23]. To create that binary image, we have used inRange() function of OpenCSV library [24]. After generating the skin mask, we have used another function GaussianBlur of OpenCSV library, which suppresses the noise and preserves the boundaries.
c. Clustering: Now we have grouped the identical pixels together to extract the dominating color (skin color) in the image. We have used K-means clustering present in Scikit-learn library.

iii. Dlib's Haar & Histogram Oriented Gradients based face detection:

First we need to detect and locate face in the given image, in order to do that, we have used HoG based method as this method is really good other than deep learning ones. HoG based face detection method is provided by dlib [25] which is a computer vision library. This method returns 68 point mapping of the face including different parts like eyebrows, eyes, corner of mouth and the jaw line. This face detector is trained on thousands of images and is a very light-weight model which can perform well on computer processors. It returns the coordinates of rectangles drawn around facial features which can be used in cropping and analysis. We can just turn the X & Y coordinates to opposite so that we can have hair regions for hair color extraction.

iv. Calculation of Feature size:

We need to now calculate the feature size to classify that into small, medium and large categories. We have used the coordinates returned by above function to find out the facial area covered by that feature, so that we can divide that by the total area of the face. These values were used against thresholds defined for different sizes for eyes, nose, lips etc.

v. Color Detection:

We need to extract the colors of eyes, lips and hair for dosha identification. We will find out the dominant color of corresponding feature by using K-means clustering algorithm. We will group the identical pixels together and form 5 groups of different dominating colors. Out of these, we will pick the most dominating color and use the same for further analysis.

Since we have the dominant colors of all features, we now need to map them with corresponding English color names. We have used kd-tree algorithm for finding the nearest neighbor of a given color [26]. Using this method, we created a dictionary of different colors with their mapping where keys are the target categories (i.e. fair, wheatish, and brown for skin) and the values are the lists of

possible shades of it (different colors' English names). For iris color identification, we cropped the eye region further and used the same method for color classification.

vi. Hair Texture Identification:

Hair texture analysis is a very complex process for machine learning; hence we need to use deep learning for the same, where we need not to prepare the feature set manually. Since we have less number of images in our dataset for training, we will use transfer learning. In transfer learning, we have pre-trained models (with weights) on millions of images using deep learning, which we can use for our analysis.

We have used ResNet50 model by Keras [27] for implementation. It is a deep convolutional neural network model trained on ImageNet dataset [28] with millions of images of different classes. So using this model and weights of it, we have replaced the last layer by our classification model into different dosha. We trained this model on Figaro1k dataset that we had prepared to conclude the dosha type as Vata, Pitta and Kapha based on hair features.

vii. Final Classification:

Now that we have extracted different features and figured out corresponding doshas for every feature, we need to add all of them to conclude the effective dominant dosha. As described in Table 1.1, dominant dosha can be of 7 types, Vata, Pitta, Kapha, Vata-Pitta, Vata-Kapha, Pitta-Kapha and Vata-Pitta-Kapha. Considering the score (repetition) of every dosha, we will sum them up for all the individual feature doshas, which should give us the final dosha in a body. We can tweak the output by calibrating the parameters with different weightage, based on the dominance of different features like body build type etc.

C. ***Experiment Setup***

In order to perform our experiment, we have used the following setup of hardware and software:

i. Hardware:
- Processor: 2.20 GHz Intel i5
- RAM: 8 GB
- OS: Windows 10

ii. Software:
- Anaconda Navigator version 1.10.0
- Jupyter Notebook version 6.1.3
- Programming Language: Python 3.8.0
- NumPy 1.19.2
- Pandas 1.2.4
- CV2 3.4.14
- Dlib 19.22.0
- Sklearn 0.22
- Imutils 0.5.4
- Matplotlib 3.4.2

iii. Cloud:
- Google colab notebook
- Keras Package preinstalled in Google colab

III. RESULTS

As we have already seen that we have used various methods for analyzing different features that contribute in predicting the dominating dosha in the human body. As we had trained the hair classifier using ResNet50 transfer learning, which yielded the training accuracy to be 95.6% and the final testing accuracy on our dosha dataset came out to be 85.2%. Using this model, we were able to classify the texture and the color of hair properly into categories like curly, straight, wavy or bald. The other factors that could further enhance the accuracy of our model like volume of hair, condition of hair (oily, dry etc), could not be determined. Since most of the pictures in our dataset had straight hair, most of the results concluded Pitta dosha. Similarly, we had used body build type analysis as another feature, which as per our training, yielded 74.5% accuracy and on the final testing dataset the same yielded 71% accuracy. Since most of the people in our dataset were medium built, dosha classification resulted mostly into Pitta category and then secondly Kapha category as second domination. Hence, using the output of hair type and body build type analysis as a score, we could predict the final dosha more accurately.

Including all the features that we had considered for dosha analysis and adding their respective scores into the final score that could determine the dominant dosha, we found that the accuracy of this whole practice was around 61% (breakup shown in Fig. 3.1). We can tweak the accuracy further by including some advance features into the feature set, as currently we have body build type, hair and facial feature colors and sizes but there can be some detailed texture or condition predicting features like we discussed oiliness, dryness etc, which would certainly help predicting the dominant dosha better.

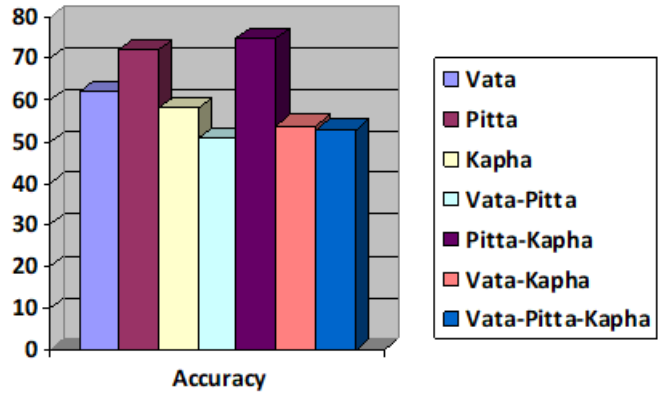

Figure 3.1 Accuracy plot for the model (in percentage)

IV. DISCUSSION

We understand that each individual has a different combination of physical features, which we take into account for Ayurvedic diagnosis. These features depend upon many factors like the environment an individual is born and living in, genetics of individual's parents and lifestyle of an individual. The same can be co-related from our results, as we had dataset of different people belonging to different regions in terms of geographic & climatic conditions and having different lifestyles; hence we saw the similar kind of diversity in our results. As we know that Vata dosha is related to air element, the same can be found dominant in the people staying in dry region, similarly the people living in coastal areas have Kapha as dominant dosha due to the presence of water element in the surroundings. Also, in general most of the people in our results were found to be of hybrid dosha with two doshas dominance, which concludes that most of the people have hybrid doshas in their bodies and relatively less number of people can be classified into single dominant dosha or even tri-dosha.

As discussed, in Ayurveda, we have many ways to correctly analyze the dominant or imbalanced dosha, which if we combine, can deliver much accurate results of the imbalance. For example, if along with physical feature classification (Darshna based), we take into account, enquiry analysis of the condition (Prashna based) and pulse reading from the wrist (Sparsha based), the same can increase the accuracy of the prediction model to a significantly high number. Since we were using photographs for analysis, that also adds another layer of difficulty because of various reasons related to the quality of those photographs in comparison to the face-to-face analysis. To conclude, we still have achieved a good milestone with this research, which can be used to take a quick reference by an individual or a skilled practitioner in order to diagnose the imbalance of doshas in somebody. This can serve a good purpose if given as a handy mobile application, using which people can simply click their pictures and identify the dominance and imbalance of their doshas and tweak their lifestyle for any improvement.

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