A Survey based on Skin Segmentation Algorithms

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***Abstract*: Skin segmentation algorithm is used in computer vision based human machine interaction applications, such as face detection, human motion recognition, video surveillance systems and hand gesture analysis. The main aim of the skin detection is to determine skin regions in an image. Skin detector is also used to identify background areas. Recognizing the human skin in complex images proved to be a difficult problem because the skin color can vary greatly in appearance due to many factors such as lighting, aging, imaging conditions, race, complex background, etc. In this work proposes the survey of various methods of skin segmentation.**

***Index Terms:* Surveillance, segmentation.**

I. INTRODUCTION

In skin segmentation, the pixels in an image are classified as skin pixels or non-skin pixels. The main objective of the skin detection is to find out skin regions in an image. A skin detector is able to accept skin tones under different illumination conditions. We know that skin detection is a wide research area in which so many works are already done.

Skin segmentation algorithms are used to detect human body in computer vision based human machine interaction applications, such as face detection [2], human motion recognition[3], video surveillance systems [4] and hand gesture analysis [5]. For example, face detection is accomplished by taking out the joint facial characteristics and by employing skin color detection as a primary step to specify the face area. As a result, accurate and fast face detection can be accomplished.

We categorize the existing methods for skin segmentation into four broad categories: non-parametric classifiers, parametric classifiers, explicit skin classifiers and dynamic classifiers. In the non-parametric classifiers, a set of training data is necessary for estimating the statistical model of skin color distribution [6]. The advantages of the classifiers are skin distribution shape independence and quick training [7]. Nevertheless, such classifiers are not precise enough because of the requirement for an unbounded amount of training information, which makes them appropriate in a constrained scope of imaging conditions [8]. In this method use Bayesian theory for applying decision rules to determine the probability values for each pixel given a particular color value. Here skin pixels are considered as a pixels with values that are larger than a preset threshold. Parametric classifiers can be based on a single Gaussian model [9], a mixture of Gaussian (MoG) models [10], or an elliptic boundary model [11]. Generally, the characterization speed of these classifiers is slow. In fact, they need to process each pixel individually. Additionally, these methods have low detection accuracy, as they approximated parameters rather than authentic appropriate skin colors [7]. Explicit skin classifiers used to segment skin points by defining decision boundaries in a color space. This avoid the problem of overlapping between some skin and non-skin pixels in a single space [2] and use of segmentation results from several color spaces. Here skin pixels are considered as pixels are located in these intervals. Dynamic classifiers cannot not use any fixed decision boundaries. Here boundaries are updated according to certain rules. Finally built a statistical model of these distributions based on skin color distributions of faces in an image to segment skin pixels in the same image.

In this work, we are considering different methods for skin segmentation. Various skin segmentation methods are K means clustering method, dynamic thresholding method, differential evolution method, multilayer perceptrons, machine learning methods, Bayesian network methods, stacked autoencoder.

The entire paper is organized as follows: Section I gives the introduction, Section II describes over the description of various techniques of skin segmentation in literature survey section, Section III concludes the paper, followed by the references.

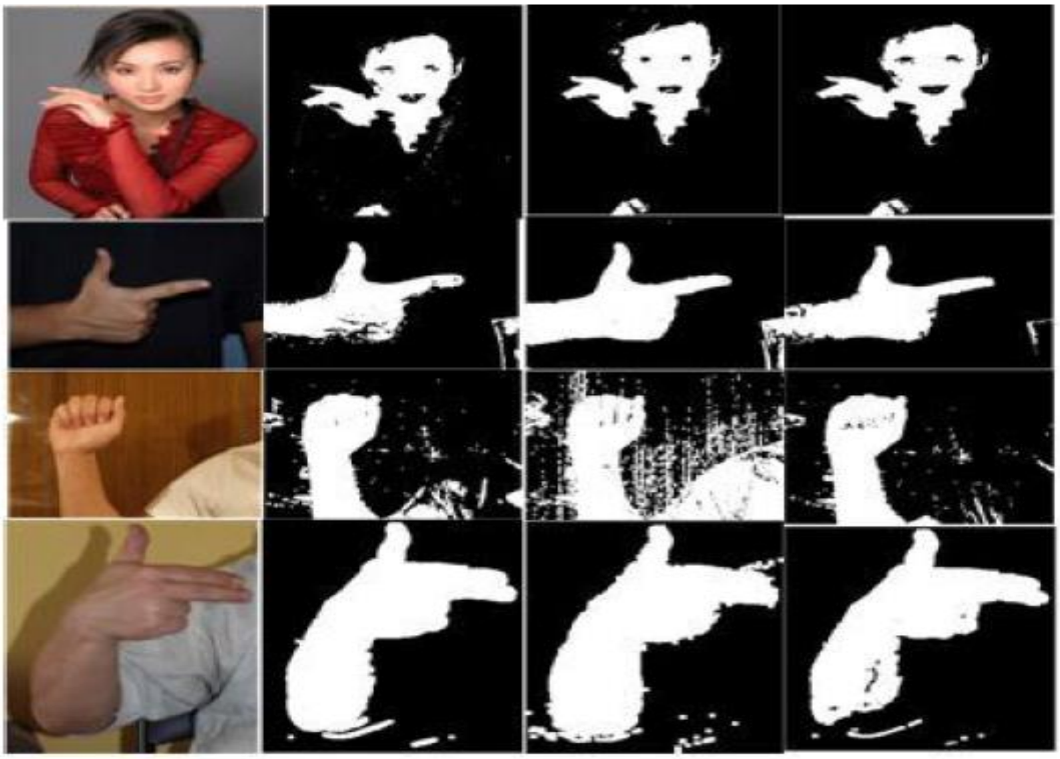


Fig.1. Example images of skin segmentation

II. LITERATURE SURVEY

This section includes various methods used for skin segmentation methods.

A. k-means clustering method

The k-means algorithm is an algorithm to cluster n objects on attributes into k partitions. The k-means algorithm is a simple splitting way of clustering analysis. Clustering is the process of classification of objects into different groups more precisely. k-means is a popular unsupervised learning algorithm that is used in a wide range of applications, such as data mining, because of its simplicity [12]. The purpose of k-means clustering is to separate n observations into k clusters so that each observation is assigned to the cluster with the nearest mean. Each cluster has a centroid, and the centroids should be defined and distinct from each other. After defining k centroids, the next is to take each point belonging to a given data set and associate it with the nearest centroid. The groupage is completed when no point is pending. Finally, k new centroids can be redetermined as barycenters of the clusters resulting from the previous step. After that, a loop is used to bind the same data set points and the nearest new centroid. During the loop, the k centroids change their location step by step, and the loop stops when no more changes can be made. In addition to its simplicity, k-means works well with large datasets. If k is small, k-means may be computationally faster than other techniques such as hierarchical clustering [13]. It can be employed in many fields, such as medical image segmentation [14], brain tumor detection [15], and content based image retrieval [16].

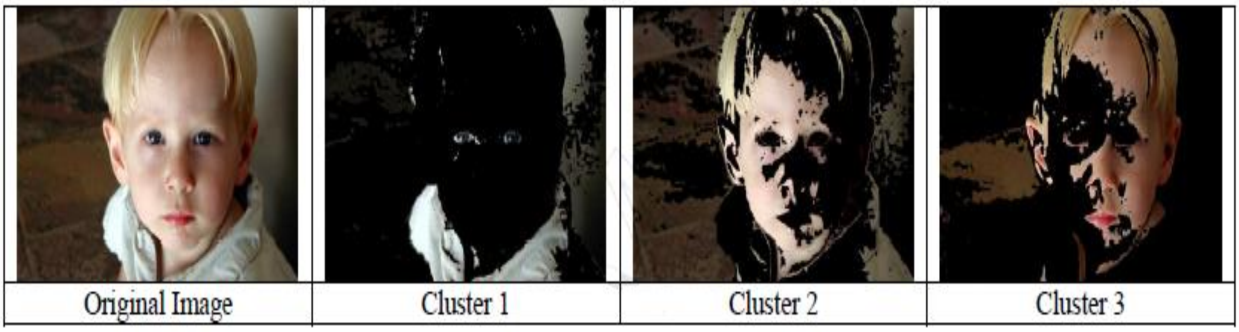


Fig. 2. Segmentation of image using k-means clustering (k=3)

Figure 2 shows an example of segmenting an image using k-means clustering. It is obvious that approximately half of the skin area is in cluster 1 and the other half is in cluster 2. That means half of the skin area will not be detected as the ANN will select only one cluster. As the result, the accuracy of detection will decrease.

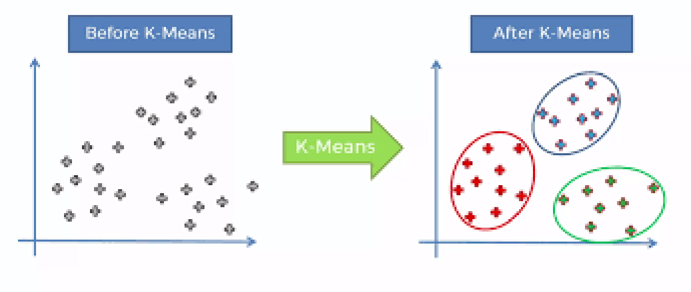


Fig.3. k means clustering working

B. Dynamic Thresholding Approach

A new skin segmentation technique for color images that makes [17] intelligent and robust to separate skin from, non skin which have colors more similar to skin. But we find the fixed threshold used in [17] is limited in separating skin and non skin in color images. So instead of fixed threshold values we calculate dynamic threshold values via on-line learning by taking the color information of human face regions. This method also takes advantage of the fact that the face and body of a person always shares the same colors. This technique performs better than the fixed threshold skin segmentation proposed previously [17].

C. Differential Evolution (DE) method

DE is a simple and fast heuristic search method that simulates the basic idea of organism evolution [18]. To continue, the MET approach attempts to solve specific problems Identify the candidates field decisions. It is used for multidimensional real-valued functions without using the gradient of the problem being optimized. In contrast to classic optimization methods, such as gradient descent and quasi newton methods, DE does not require the optimization problem to be differentiable. Therefore, DE can also be used for optimization problems that are discontinuous, noisy and variable over time. In addition, the DE algorithm has less tunable parameters and has the ability to self-organize. The simplicity and ease of implementation make the DE algorithm very popular and this algorithm can be exploited in a wide range of applications such as digital filter design [19], shape reconstruction [20], and digital image watermarking [21]. When DE is used to optimize a function with n real parameters, the DE will generate a population of candidate solutions within predefined boundaries. All candidate solutions are tested and evaluated trying to locate the minima of the objective function. If the Optimum solution is not reached, a genetic algorithm is used to generate another population. During each iteration, called a generation, new candidate solutions are generated by the combination of solutions randomly chosen from the current population (mutation). The outcoming solutions are then mixed with a predetermined target solution. This operation is called recombination and produces the trial solution. Finally, the trial solution is accepted for the next generation if and only if it yields a reduction in the value of the objective function, i.e.the stop criterion.

D. Multi-Layer Perceptrons (MLPs)

Multi-Layer Perceptrons(MLPs) are applied in many pattern recognition problems. MLPs learn a lower dimensional representation of the input image by detecting various edge like features. MLPs are applied in many pattern recognition problems. These features are mainly used for classification. Though they are able to efficiently extract features from non natural images, they are not able to do so with natural images like human faces. This happens mainly due to the presence of redundant parameters in MLPs which occur because of full connectivity in them. MLPs, is a type of artificial neural networks (ANN), are feed forward networks of simple processing elements or neurons. The weights in the network are updated iteratively through a gradient descent technique known as back-propagation algorithm. In the training process at each iteration, the MLP processes all of its inputs in a feed-forward fashion, compares the resulting outputs with the expected ones and back-propagates these errors to adjust each weight in the network based on the error. In MLP-based skin classification, a NN is trained to learn the complex class conditional distributions of the skin and non-skin pixels. The NN classifies the image regions as a collection of either skin or non-skin regions. The skin classification obtained from NN is subjected to further fine tuning using a Gaussian model.

Original image Ground truth Output of the ANN

Fig.4. Three areas in the output of the MLP ANN: 1. Skin 2. Non-skin 3. Skin-like

E. Machine Learning Methods

Machine learning methods, such as support vector machines (SVMs) [22,23] and artificial neural networks(ANN)[24,25], have been applied to skin segmentation problems. These take a set of pixel feature vectors as input, to find a suitable parameter space, which is then used to initialize the model and to segment newly considered pixels by comparing the model's output against a certain threshold. These methods mentioned above have been successfully applied for human skin detection. However, they still suffer from a lack of robustness against skin color variations caused by different ages, ethnicities, illuminations, and other factors. Propagating the "skinness" from seed points to their neighbors appears to offer a way to overcome this problem [26,27].

E. Bayesian Network Method

Bayesian network is a directed acyclic probabilistic graphical model (a type of statistical model). Graph with each vertex represents a set of variables and edges represents their conditional dependencies. Two examples of Bayesian Network classifiers are the Naive Bayes (NB) classifier and the Tree- Augmented Naive Bayes (TAN) classifier. The NB classifier is a classification technique based on Bayes Theorem . Here assumes that all the features are conditionally independent given the class label, though this is not always true. Tree Augmented Naive Bayes (TAN) is a graph structure, in which a single class variable have no parents but all other variables have the class as a parent and at most one other attribute as a parent.

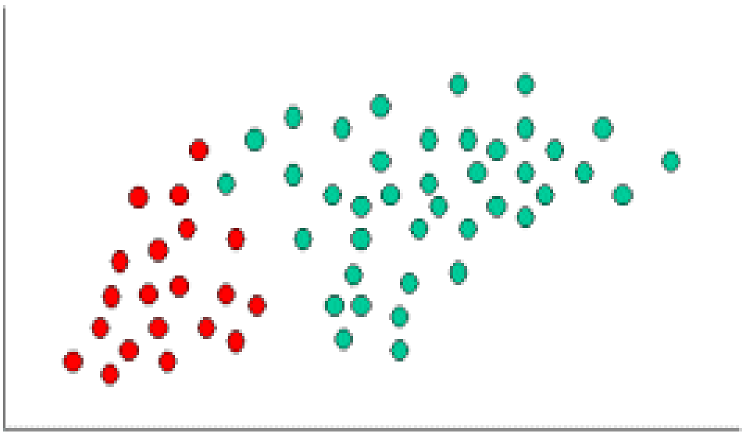
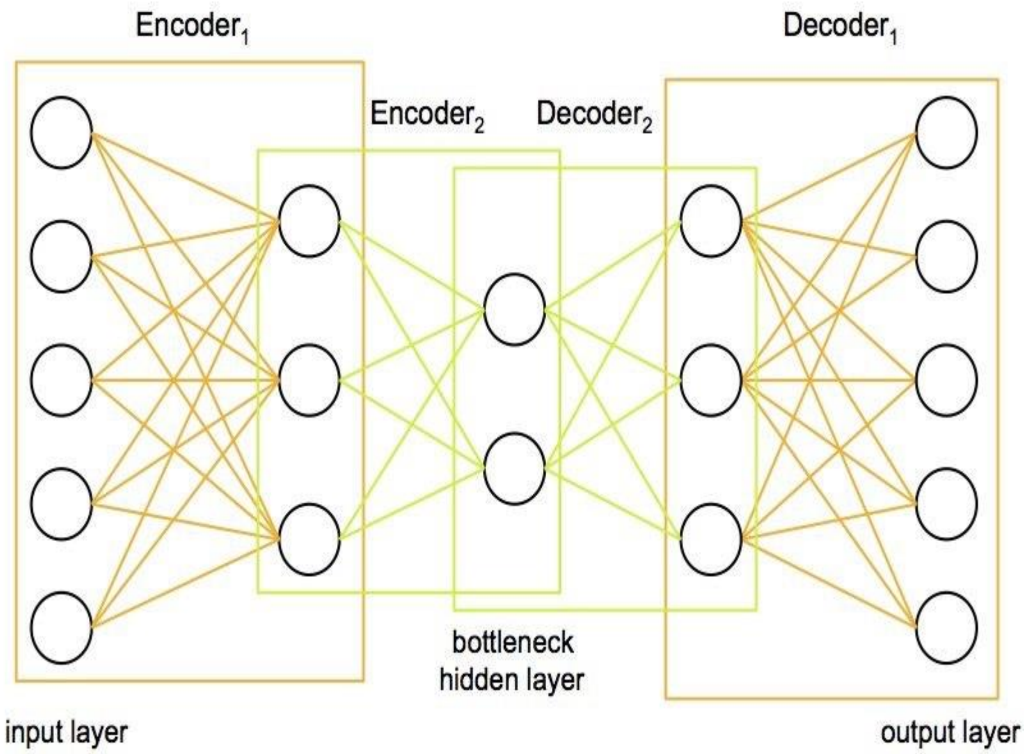


Fig. 5. Naive Bayesian Example

G. Stacked autoencoder

Stacked autoencoder is a deep neural network consisting of multiple layers of sparse autoencoders. Here, the output of each layer is included in the next layer. Autoencoder performs both encoding and decoding tasks. Autoencoders that encode input data as vectors. These are useful in dimensionality reduction, the vector compresses the raw data into smaller number of essential dimensions. In decoding task, which allows the reconstruction of input data based on its hidden representation

Fig. 6. Simple architecture of Stacked Autoencoder



In stacked autoencoder algorithm, we detect skin pixels based on features that are learned from blocks rather than individual pixels. The skin tones in an images can be detected by scanning them sequentially using a sliding window. All these blocks are converted into a matrix consisting of 1s and 0s corresponding to skin pixels and non-skin pixels respectively and is predicted by the stacked autoencoders. Then to learn the distribution of the skin pixels, our training data include skin information from Asians, Europeans, and Americans. The skin blocks are taken from different areas of the human body, such as the hand and neck. Finally, we train the network on multiple color-space dimensions, such as RGB and HSV, to learn a complex representation containing illumination information. A fusion step is applied to identify and retain the good representations from the different color spaces while removing some of the noise. Main challenges in the traditional skin segmentation is false positive rate and overlapping of skin and non- skin pixels. Stacked autoencoder used to avoid this problems. Stacked autoencoder is used to find higher level representation of skin areas.

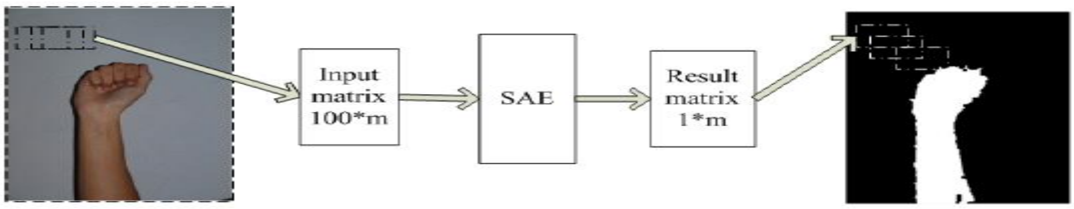


Fig. 7. Stacked Autoencoder Example

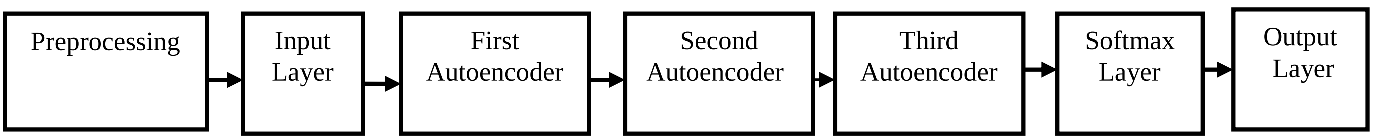


Fig.8. Stacked Autoencoder Framework

In Figure 8 shows Stacked Autoencoder framework. Three autoencoder layers are designed to learn the representation of the blocks. Softmax layer is used to classify the feature vector. Output layer predicts whether a block is a skin block by outputting its probability of being skin.

III. CONCLUSIONS

In this paper, we presented an extensive survey of various techniques used for skin segmentation. Skin Segmentation is mainly used in biometric applications. A good skin classifier must be able to separate skin and non-skin pixels for a wide range of people with different skin types such as white, brown and dark and be able to perform under different illumination conditions such as indoor, outdoor and with white and non-white illumination sources. From the survey, understood the methods for skin segmentation like K means clustering, dynamic thresholding, machine learning methods, multi layer perceptrons, differential evolution methods etc. Gone through several research works based on these methods, analyzed the working and their drawbacks.

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