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Face Detecting and Recognizing using 3D local Binary Pattern

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Abstract

This study focuses on improving face detection and recognition by using a 3D Local Binary Pattern (3DLBP) approach. While traditional 2D Local Binary Pattern (LBP) methods have been widely used for texture classification, they often fall short when dealing with the complexity of 3D facial textures. To address this limitation, the research applies an enhanced 3DLBP method using the Texan 3D facial recognition dataset. The process involves extracting facial texture features and classifying them through a Support Vector Machine (SVM) to achieve higher accuracy in face recognition. The results reveal that 3DLBP significantly improves recognition performance, especially when distinguishing facial features from different angles and expressions. The findings highlight the potential of this approach for real-world applications such as security, biometric identification, and crime prevention. The paper emphasizes the importance of incorporating more diverse facial data to further refine and optimize the accuracy of live recognition systems.

Keywords: 3D Local Binary Pattern (3DLBP); Face Detection; Face Recognition; Support Vector Machine (SVM); Texture Analysis.

1. Introduction

Face recognition is the method of assessing the identity of a person's face inside digital photographs. Face recognition uses machine learning and formulas known as algorithms to identify human faces inside more images. Any wide photographs have landscapes, buildings, and other pieces of people that were not faces (e.g. legs, shoulders and arms) [1].

Face Detection is distinct from Facial Recognition in the way that it does not require the search for a recognized particular entity. It literally means that the face recognition device may recognize that there is a human face present in a picture of film. Face detection is a part of facial recognition technologies. Utilization of facial recognition techniques will also help operate optical cameras and smartphones to enhance autofocus.

1.1 Problem Statement

Face detection and recognition is one of the most important studies in our days. The texture of face is actually represented in 3D. Whether the LBP is representing objects in 2D therefore extending and enhancing the face detection and also recognizing the identity of person by face texture using 3D Local binary pattern. Identify a person from his face texture helps in many fields, for example in reduce crimes or also in college attendance and person physical representation.

1.2 Objectives

- To enhance the object detections.
- To recognize the identity of person from texture of image.

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- To minimize the error of object detections.

1.3 Motivation

The motivation for this research comes from the growing need for more reliable and accurate face recognition systems in our daily lives. From enhancing security to improving access control, face recognition has become an essential tool. However, traditional 2D methods often struggle with accuracy, especially when facial features change due to different lighting conditions, poses, or expressions. This gap inspired the exploration of more advanced techniques that can better capture and analyze the full depth of facial textures.

By adopting 3D Local Binary Pattern (3DLBP), this study aims to improve recognition accuracy and reliability. The ability to recognize individuals through their unique facial texture can make a real difference in fields like security, crime prevention, and attendance tracking. Ultimately, this research is driven by the desire to develop a practical, real-world solution that leverages the latest technology in machine learning and image processing to address these challenges

2. Related Work

Guoying Zhao and Matti Pietikainen, performed DT recognition process for facial expressions with an application to facial expression recognition. This study suggested a novel approach for recognizing DM (dynamic textures) and DTs (local binary patterns). In order to support visually disabled individuals, textures are designed first with volumetric scattering. just certain binary patterns which are co-occurring on three orthogonal planes are used for combination evaluation. There are unique complex situations which were only caught by a block-based approach which also have to be taken into account. The argument that it was recommended to include recognition of the shifts of facial expressions while viewing videos is also possible. In experiments using two existing DT results, a VLBP approach outperformed previously suggested LBP-TOP and The approach established is highly cost efficient. The findings of the facial expression recognition in this study proved to be successfully accomplished with the block-based approach.[4]. While another experiments referred to F. Baumann et al was used for volume local binary pattern applied to Action Recognition as to test a binary pattern more steps are needed to build a discriminative function. Researchers in their paper have suggested a new computing approach to improve the accuracies of Volume Local Binary Patterns, KTH and Weizman datasets [5]. Moreover Here, the author proposes a fascinating concept with VLBP model. These methods are used to remove a function of Volumetric Local Binary Pattern (VLBP). Hexagonal Volume Local Binary Pattern Descriptor achieves better outcomes than Other Experimental Geometric shape-based Neighborhood Selection methods used to detect human behavior. This example shows how well the methodology work in real-time world.[6].

Bharti Rana et al had good work done due to easy and effective FFD, about the three main tissues of PD, cortex, and regional white matter. Each brain volume is defined in terms of the fdd. Then each brain region is segmented into segments that are then categorized using a 3D local binary pattern. Thereafter a number of useful features was defined using a t-test in association with the minimal redundancy maximization and relevance selection strategies. The outcome of the analysis that tissue properties can be interrelated between each other. This approach may be used as a screening instrument to analyze PD[7]. Also, Kim Joong-Rock et al proposed An adaptive local binary pattern (ALBP) for 3D hand tracking. ALBP is an important feature extraction technique for depth image-based applications. These authors showed the utility of the proposed ALBP by showing how well the device operates with traditional depth pictures[8]. Using local binary patterns (LBP) derived from texture-based facial expression recognition tasks, R.Ameen et al a conducted a study of local binary patterns in various color models for individual independent facial expression

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recognition. The effects of various color models were majorly influenced by identification output in object categories[9]. Kamil YURTKAN et all applied entropy driven feature selection for facial expression recognition based on 3D facial feature distances using entropy-based feature selection for a 3-dimensional (3D) geometric facial feature-based facial expression recognition system by dividing human facial expressions into 6 main classes. To distinguish the geometric activities on the face during facial expressions and they used entropy-based original feature selection and they achieved Promising results on the system tested on the BU-3DFE database [10]. Xiaoli Li 3D face model" have been represented in 2D-image-like structure, which enables us to take advantage of the wealth of 2D methods to analyze the 3D face models. " Then this improved facial representation based on a topographical gradient of topological objects (solid norms, meshes, polyhedral cells) is proposed. To introduce novel approach for 3D facial expression detection of a holistic, automated manner. For dealing with the 3D facial expression recognition, the research team had a remarkable approach, and that helped them to directly obtain incredible achievements.[11]. Also Shiwen Lv et al published an article an add-on for 3D face recognition systems is an Area Based Extended Local Binary Pattern (eLBP) which is proposed to classify faces. The depth image is converted from the pointclouds and normalized. And, based on facial expression bias, participants are categorized as extremely moderate, positive, neutral, bad, and then very negative. This is the reason why SRC can be used for grouping. When the algorithm was tested, the researchers found that the algorithm is resilient to the expression by hybrid deformations and score-level fusion with W-SRC that improved the efficiency and is better than the feature-level fusion [12].

3. Methodology

Studding the 2D LBP and then extend to 3D LBP , represent the extending results , than apply the 3D pattern to selected samples of data. Finally develop blueprint showing result by using 3D LBP. First fitch the image from proposed database , secondly extract the feature using 3D LBP , thirdly recognize the face by comparing the texture with trained features and finally estimate the accuracy for recognized face. The following figure:1 represent the face recognition proposed model [2].

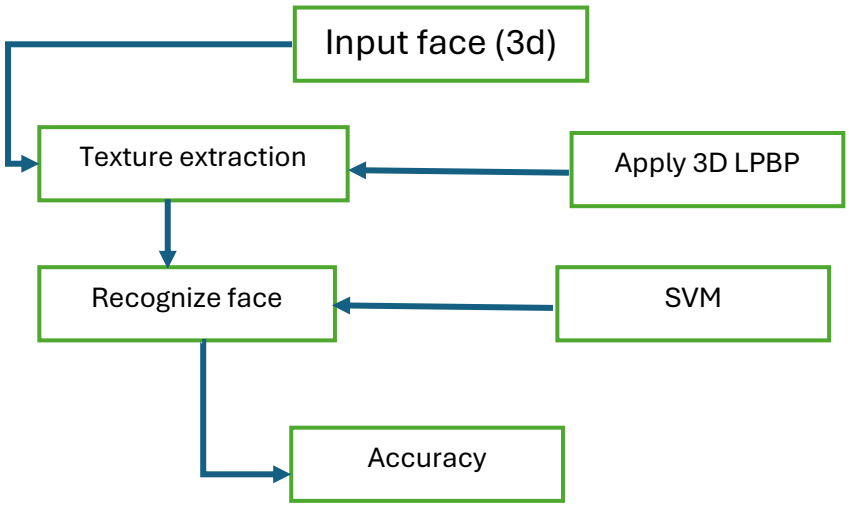

Figure 1: Proposed model for face recognizes

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3.1 Proposed Dataset

I have used the three-dimensional (3D) Texan facial recognition dataset for performance assessment. This This dataset contains 1149 trials that are corresponding in motion., The 116 recreated pictures were matching both color and movement, and very closely analyzed by a large team of academic experts. The photographs are accompanied by details about the subjects' face, both gender and ethnicity, and the face's facial features, such as the location of a 25-point facial or facial feature, taking into account the anthropometric data. Of all the knowledge introduced, the blocks that support both training and testing 3D face recognition algorithms are also included [3]

3.2 Local Binary Pattern (LBP)

The Local Binary Pattern (LBP) algorithm is a relatively simple algorithm that classifies texture characteristics. The LBP operator within Matlab corresponds to the texture characteristics of the grayscale file. In this case, a value of zero is called the middle, and any value between zero and the pixel value itself is considered to be the threshold value, which makes the image processing more difficult. The most primitive approach is to decode each column in order and take the value of the most central pixel as the threshold, and then take the sum of all the values in the image. In this case, the values can be changeable, and the threshold can be changed. However, the repetitive measurements build up memory space and carry up the processing overhead, so it is not ideal for low-power devices. The adjacent pixels are blocked out[2] .Its calculated as it shown in Eq.1:

$$\mathrm{LBP}(x_c, y_c) = \sum_{p=0}^{p-1} 2^p s(i_p - i_c)$$
$$s(x) = \begin{cases} 1 & x \geq 0 \\ 0 & x < 0 \end{cases} \quad (1)$$

The Basic LBP approach is defined by thresholding the neighborhood around the center pixel with the original pixel value. Let g c be the gray level of the middle pixel (center pixel) and gn be the gray level of each of the seven surrounding pixels. Figure.2 demonstrates the fundamental operation of the LBP. If intensity is greater than black, the pixel is set to 0, otherwise it is set to 1. Both reports are mixed together, to get the final results. The decimal value of the binary is less than or equal to LBP function.

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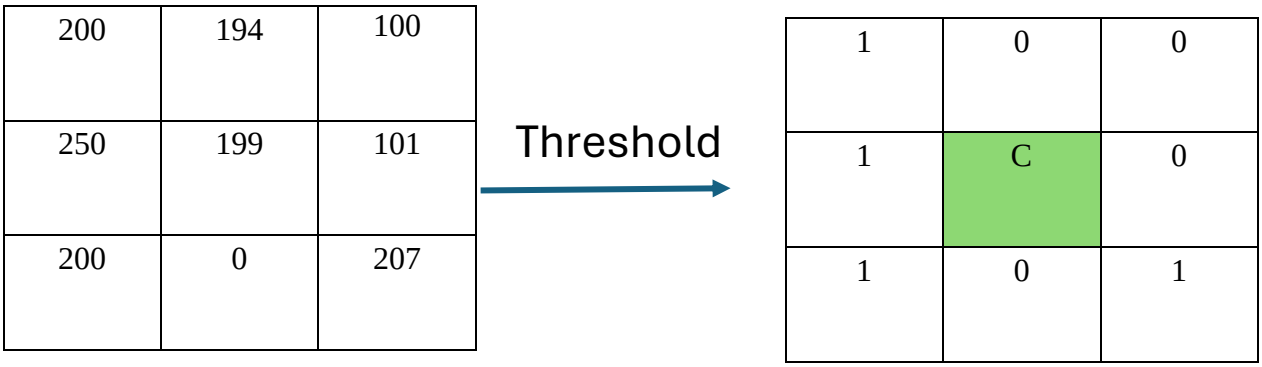
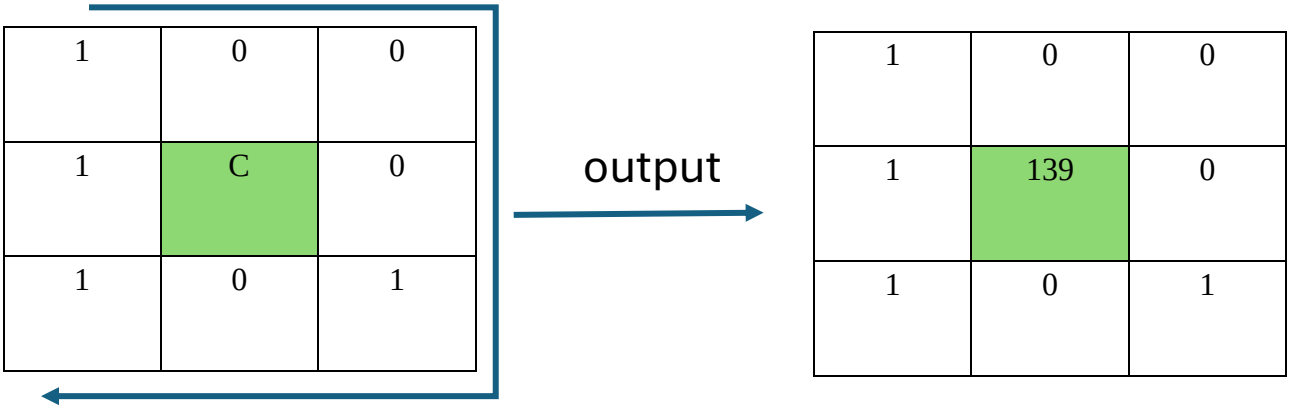


Figure 2:*:* LBP calculation process



Output = 10001011 = Decimal number 139

(10001011) $_2$ = $(1 \times 2^7) + (0 \times 2^6) + (0 \times 2^5) + (0 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) = (139)_{10}$

Start by multiplying each of the pixels on an image, and then measure the neighborhood around that central point. Compare the values of the other 8 pixels around the center with the values in the center. Setting the pixel value to 1 if the pixel value is greater than or equal to the middle pixel value and setting the pixel value to 0 otherwise. The 8 bit series of "0" and "1" will be converted into 8 bit unsigned integer binary value. After computing, the LBP eigenvector is the value in the middle of the window [2].

3.3 Support vector machine:

"Support vector machines, or SVM's for short, is a supervised machine learning algorithm which is used for both classifying and regressing data," Classification questions are most widely used in this book. Here, we have data points, coordinate values, and value of each coordinate. Following this, we characterize the data by use of linear discriminant technique [13].

The primary rule behind Support Vector Machine (SVM) is to take the linearly divisible samples on the low dimensional space and map it to high dimensional space by the kernel function. Certain indivisible and inexorable random sample sets become separable and divisible. Help vector machine (SVM) is an awesome

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approach used in, as seen in the below diagram (Figure.4) & (Figure.5), two-dimensional problem of linear separation [14].

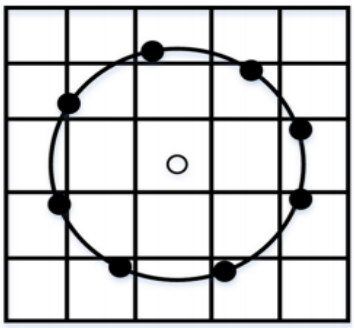

Figure 3: Diagram of circular neighborhood definition

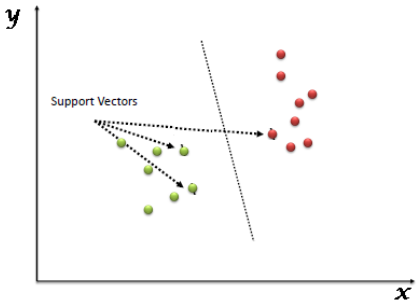

Figure 4: supported vector representation

3.4 Histogram of image:

An image is an object consists of pixels (colors) that form the image. That's right, when they blur into one, we can't even see apart one from another. The RGB (Red, Green, Blue) is an additive color model allowing each pixel to have an off-white or translucent gray-blue tint. Before we examine the color of pictures, let's first deal with the black and white images. The only colour in a monochrome picture is grey and all colour is part of the signal. 255 is the highest value used for R-Y, so this color result is bright white. Middle tones that are between saturated shades.

Image histogram is a graph mapping colors. This function is used to find the number of pixels of any colour in an image. Each bar on the "intensity" histogram represents one possible intensity. Since black reflects all values below 255 and white, the other way round. When you analyze the pixels of the high-resolution image, you can see how many color pixel each pixel has. The following example represent the histogram of an image [15].

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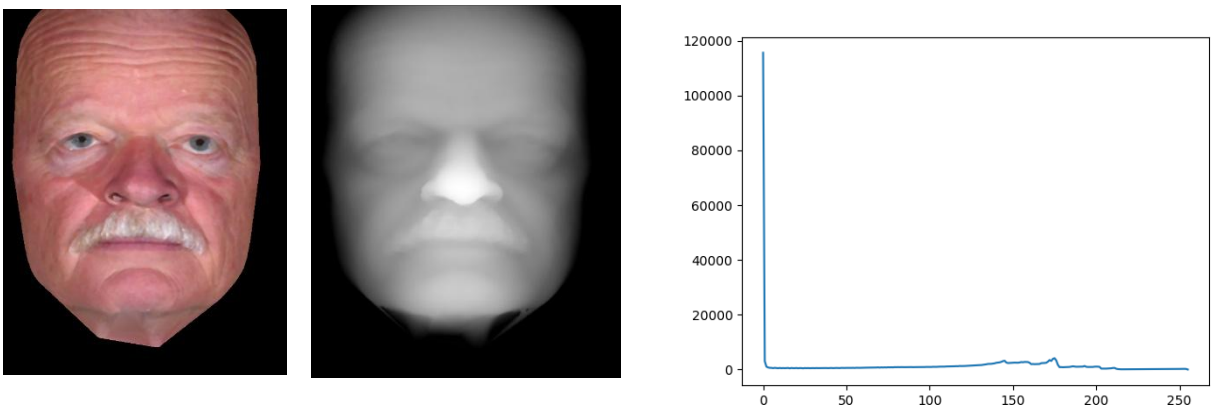

Figure 5: Histogram of image

3.5 Accuracy

This paper applies the Support Vector Machine (SVM) to maximize the performance of facial recognition (SVM). First of all, we set the radius of LBP circle to R and P and then we extract functional properties. In the second stage, we use an SVM based radial basis kernel function to identify, separate, compare and group the relevant feature information. Based on Texas 3D FDRA details retrieved, extract features of different entities and calculate a histogram using these features. Then normalize the ranges of histogram. Save all of the saved face folder to disk before create the face archive. The histogram will be calculated and converted to the 3D face depth picture of Texas to remove the physical face. Thought. The collect data from the database to the character cell and show the data on the screen. Finally, the data and the segmentation is calculated and understood.[14].

3.6 3D Local Binary Pattern (3DLBP)

The simulator used in this therapy is called the 3DLBP-TOP (LBP on three orthogonal planes). (This means that) LBP-TOP discusses the co-occurrences figures within the three dimensional spatial-spectral structure of hyperspectral imagery. This dataset contains 10 buckets that are paired along with a two-dimensional binary histogram with 10 scaled concatenated histograms from three scaled horizontal planes. Likewise, the uniformization of X, Y, and B into a single, coherent spatial space yields a set of one dimension and two dimensions. First, three 2DLBP histograms XY-LBP, XB-LBP, YB-LBP are orthogonalized at three different planes. Then, the three orthogonalized histograms are concatenated into a single histogram to generate the 3DLBP histogram characteristics. The figure.6 represent the histogram of image using 3DLBP pattern [16], [17].

Definition of VLBP as the joint distribution of gray level of 3P+3(P>1) pixel of the luminance level image was given. P is the cumulative number of points on the boundary pixels circling the center pixel. Both quantities are presented in following Eq.2 [16].

$$V = v(g_{t_c-L,c}, g_{t_c-L,0}, \cdots\cdots g_{t_c-L,P-1}, g_{t_c,0}, \cdots, g_{t_c,P-1}, g_{t_c+L,0}, \cdots g_{t_c+L,P-1}, g_{t_c+L,c}). \quad (2)$$

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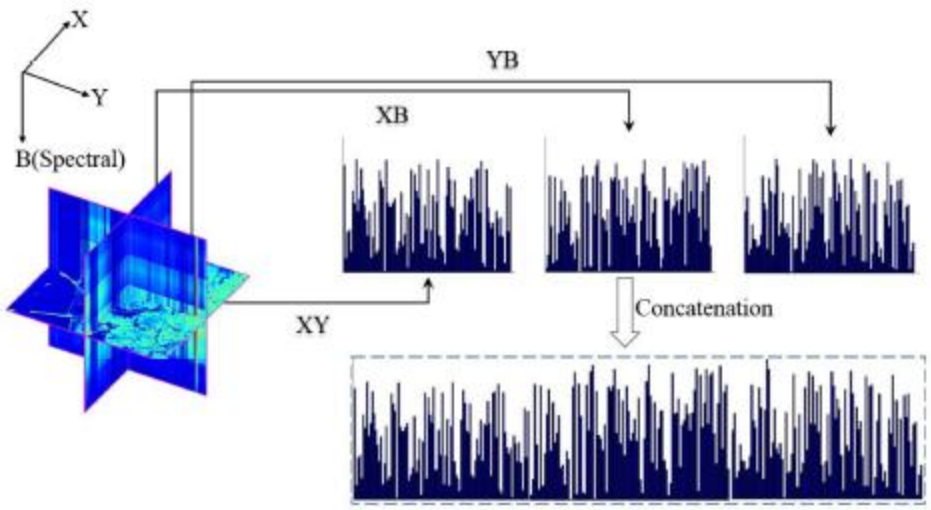

Figure 6: extracting 3DLBP histogram [17]

Volume local binary pattern (VLBPL,P,R) characterizes the spatial configuration of the complex volume textures seen in the Eq.3 [16].

$$VLBP_{L,P,R} = \sum_{q=0}^{3P+1} v_q 2^q \tag{3}$$

Figure.7 display VLBP1,4,1 computation method. First, we consider neighboring pixels in the image, and any point is then thresholded with the value of the center pixel. Finally i measure the VLBP code using the weighted pixels and add up the results.

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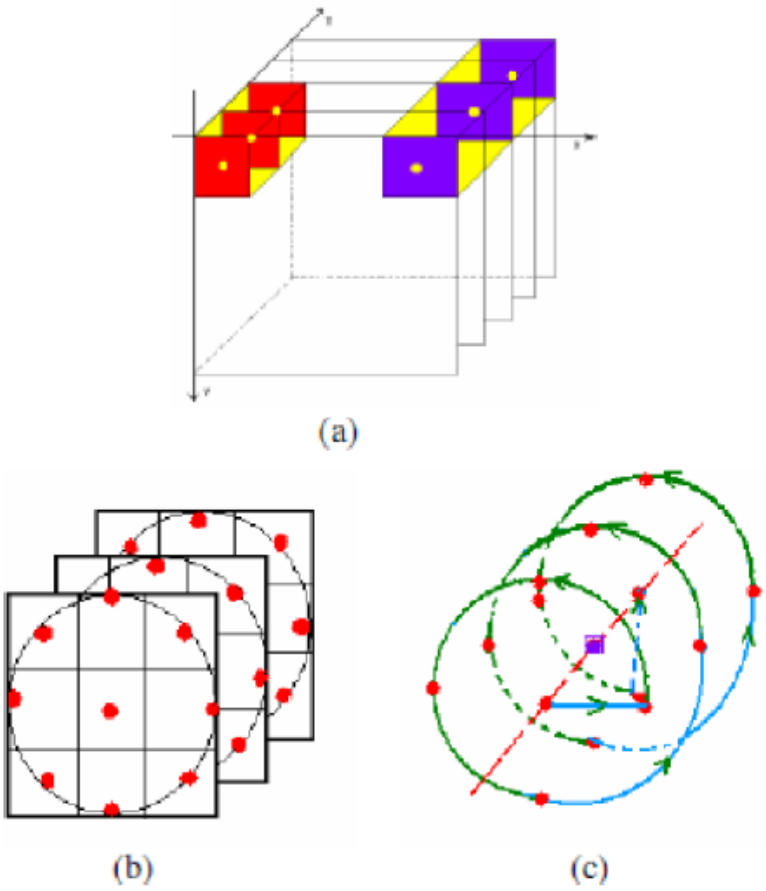

Figure 7: (a) Right longitudinal angular displacement in a complex texture, with H=1 and L=1. (b) Circularly symmetric neighbor sets in a volume, with R=1 and P=8. (c) Intersection of group of circular helix surfaces [16]

The vertical local binary patterns (VLBP) codes are first determined for each pixel in the cropped segment of the DT image, and then D is used as a function vector denoted by Eq.4.

$$D = v(VLBP_{L,P,R}(x,y,t)), x \in \{\lceil R \rceil,\ldots,X-1-\lceil R \rceil\},$$
$$y \in \{\lceil R \rceil,\ldots,Y-1-\lceil R \rceil\}, t \in \{\lceil L \rceil,\ldots,T-1-\lceil L \rceil\} \quad (4)$$

3.7 Experiments

To prove the equations and also to satisfy with results we have implement the VLBP using Python and Texan facial recognition dataset. Fetching the histogram of VLBP. In our experiment, we selected 100 samples out of 1149 faces. The need for image processing will arise in many ways. Figure.8 and figure.9

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represent the dataset sample in both grayscale and original color pictures. I have numbered the object sequency from 1 to 100 and the following figure shows the sample list

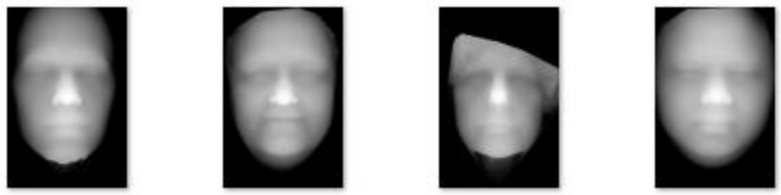

Figure 8: Grayscale sample images

Figure 9: Original sample images

Sample are converted to SVM and feed trained machine to the system to identify the person. The training matrix are feed to the system.

3.8 Experiments results

I observe that all faces has been detected and identifying when the camera are passing Figure.10 shows the results of face detections. Also, I observe that the recognizing person has been implemented and recognized when trained got enough images with different angles.

Figure 10: Face detection implementation result

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4. Conclusion

This study explored the potential of 3D Local Binary Pattern (3DLBP) for improving face detection and recognition, addressing the limitations of traditional 2D methods. By extending LBP into the 3D domain and combining it with Support Vector Machine (SVM) for classification, the proposed approach demonstrated promising results in accurately identifying faces from different angles and under varying conditions. Using the Texan 3D facial recognition dataset, the experiments confirmed that 3DLBP is effective in extracting detailed facial textures, ultimately improving recognition accuracy.

While the results show that 3DLBP works well on selected samples, it also highlighted the need for feeding more diverse and extensive datasets to achieve higher accuracy in real-world applications. Recognizing individuals in real-time settings requires ongoing refinement and optimization. The findings of this study have practical implications for fields such as security, biometric authentication, and crime prevention.

In conclusion, this research contributes to the growing field of 3D face recognition by offering an approach that balances accuracy and practical implementation. With further improvements and the integration of larger datasets, 3DLBP could become a key component of next-generation recognition systems.

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