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A Proposed Framework for Face Recognition using Enhanced Local Binary Pattern Algorithm with Chinese Remainder Theorem

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Abstract: One of the biometric methods that have recently gained attention across the globe is Face Recognition. This was due to the availability of practicable technologies, including movable results. Several studies have been carried out on face recognition for decades, but the problem is still largely unsolved. Significant progress has been made recently in this area as a result of advancements in face modeling and analysis techniques. While a system has been developed for face recognition, the problem of high processing time is still largely unresolved. This research framework proposed an Enhanced Local Binary Pattern (ELBP) algorithm for face recognition. The Local Binary Pattern (LBP) algorithm is a method used in facial feature dimensionality reduction. Standard LBP had challenges of computational complexity. Therefore, the LBP will be enhanced with the Chinese Remainder Theorem (CRT) and will be used for feature extraction to reduce computational time, Chicken Swarm Optimization (CSO) will be used for feature selection and classification will be done using a Support Vector Machine (SVM). Performance Evaluation of the system will be done by comparing the computation time result obtained from the combination of LBP-CSO and ELBP-CSO. The ELBP-CSO is expected to have a lower computation recognition time than the LBP-CSO.

Keywords: Chicken Swarm Optimization**,** Chinese Remainder Theorem, Face Recognition, Feature Extraction, Local Binary Pattern.

I. Introduction

Biometric authentication provides a normal and dependable answer to the problem of how to determine the identity through the establishment of the identity of a person based on "who an individual is", instead of "what an individual knows" or "what an individual carries". [1] A biometric scheme can be thought of as a signal discovery system with a pattern recognition architecture that detects a raw biometric signal, processes it to extract a relevant set of features, compares them to feature sets in the database, and either authenticates or regulates the identity associated with the signal. [2] 'Biometric facial recognition can be regarded as one of the utmost importance and swiftly evolving artificial intelligent technologies presently obtainable for security and law enforcement purposes. [3] It is progressively spreading all over the world as a very safe and dependable security technology [4]. Also, a Face recognition scheme can capture biometric parameters of a human being from a precise interval lacking mingling with the human being. [4] Right from the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), or "COVID-19', outbreak there has been even more eagerness about the idea of contactless security such as FRT. [5]

The Local Binary Pattern algorithm is a method recently applied for dimensionality reduction of the facial image features in a dataset, and it

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increases interpretability, but at the same time reduces information loss. [6]

Several pieces of literature have been published on facial recognition systems that use various algorithms. A Secure Rotation Invariant Face Detection System for Authentication (NIFDS) using the method of combining Polar Harmonic Transforms (PHT) technique with Multi-Block Local Binary Pattern (MBLBP) in a hybrid manner to fast and accurately detected rotated faces was proposed to implement a robust method for her face detection taken at a various angle to achieve a better result than know algorithm for face detection. [7] The researcher was able to detect faces at varying angles and different image resolutions with high accuracy but was unable to reduce processing time and computation complexity. In related work, Towards Optimizing Cloud Computing Using Residue Number System was developed and used the method of constructing distributed data storage systems based on a system of residual classes. The use of direct data conversion from a positional number system to a system of residual classes will have great computational complexity; the use of modules of a special kind allows for solving this problem. [8] The researcher was able to establish that the application of parallel processing will reduce processing time when apply in real-time operation. In another work, Multi-Object Face Recognition Using Local Binary Pattern Histogram and Haar Cascade Classifier on Low-Resolution Images was introduced and used the method that improves face recognition results by the use of a histogram to represent the number of occurrences of each binary code in patches of the image data. to build a face recognition prototype that can recognize multiple face objects within one frame and use a local binary pattern histogram and Haar cascade classifier on low-resolution images. [9] the researcher was able to achieve high accuracy but was unable to determine the processing time.

Some examples of feature extraction techniques are LBP and LBP which is one of the geometric/template-based algorithms had been known for their computational complexity during feature extraction. There is a need to reduce the computational burden by introducing a Chinese remainder theorem method as recommended by. [10] Hence, this research developed an Enhanced Local Binary Pattern (ELBP) by applying the Chinese remainder theorem method of Residue Number System (RNS) to standard LBP for face recognition systems to lower recognition processing time.

II. Materials and Methods

The following variables will be used to complete this study:

i. Six hundred (600) Facial images of two hundred (200) subjects, (200x3=600).
ii. Gotten from a local source with the use of a digital camera.
iii. Background illumination that is consistent and has low-level noise.
iv. The KWASU dataset, which was developed locally.
v. Conversion of the input image to grayscale

A. Hypothesis: H1 (Alternate Hypothesis)

That combining an enhanced feature extraction algorithm, feature selection, and classification can significantly reduce computational recognition time. The proposed framework is depicted in Figure 1 below.

This research will have these approaches, first, enumeration of facial images that are available in the datasets, and the decision on how many facial images to adopt for training and testing. The normalization of the images to enhance the local contrast will be carried out. Secondly, a feature extraction algorithm will be used to extract features from facial images in the dataset.

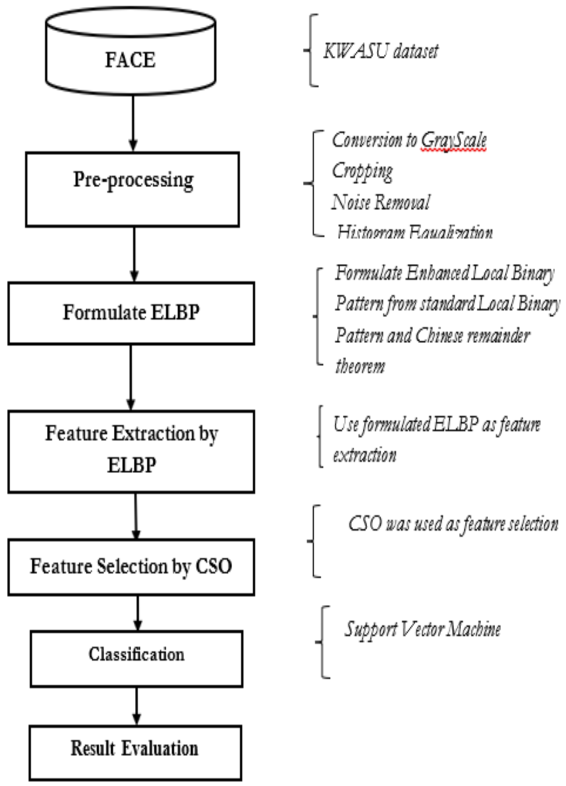

Figure 1: Research Proposed Framework

Thirdly, a feature selection algorithm will be applied to select the relevant features from the extracted features from the images in the dataset. Fourthly, the classification of feature vectors will be done. Thereafter, performance evaluation of computational recognition time will be done by comparing the combination of the feature extraction and feature selection techniques used. This process is enumerated in figure 2 below.

B. Data Acquisition

A local dataset called KWASU named after Kwara State University will be adopted for this research work. Facial images will be collected into the dataset which will be gotten by capturing a person using a camera locally. 600 facial images will be captured through snapping of 200 individual persons, with 3 images per person. 360 facial images will be adopted for training while 240 facial images will be adopted for testing. Table one below shows the breaking down of the acquisition of images.

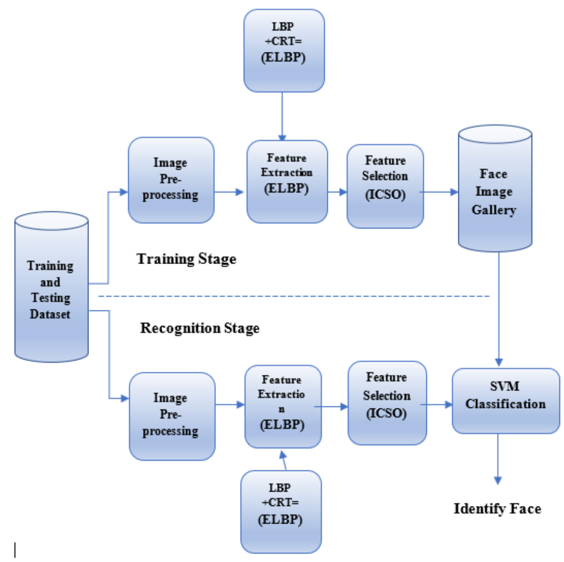

Figure 2: Schematic Diagram of Face Recognition Process

Table 1: Breakdown of images

Number of objects (persons)	200
Number of samples per object	3
Number of total samples	600
Number of the training set	360
Number of testing samples	240

C. Pre-processing

Pre-processing includes Sequential operations. Image pre-processing entails actions such as adjusting image brightness, contrast alteration, scaling, filtering, cropping, and other procedures that aid in image enhancement. Pre-processing will be done in this step, which will include converting colored photos to grayscale, cropping the image, and normalizing face vectors by computing the average face vector and deducting the average face from each face vector.

This will be done to reduce noise from the images of people's faces.

The histogram equalization will be used as an image normalization technique, with the image's intensity spread using the cumulative distribution function. The image intensity values will be distributed using the cumulative distribution function. This function finds out the transformation that maps input image grayscale values to transformed image grayscale values.

D. Feature Extraction

Feature extraction is a dimensionality reduction process, with an initial set of the raw data divided and reduced to more controllable groups It is used to extract the most useful and unique features of the face image. Their features can be processed easily, and are still able to describe the real data set with their accuracy and originality. Local Binary Patterns will be Enhanced with the Chinese Remainder Theorem and adopted for the extraction of features. The reason is due to its discriminative power and computational straightforwardness and the method seems to be quite robust against face images with different facial expressions, different lighting. conditions, image rotation, and aging of persons [10] Also, CRT is an example of a Residue Number System (RNS) and is a theorem that can frequently be enjoyed to increase the speed of computation.

i. Local Binary Pattern (LBP) Algorithm.

Local binary pattern (LBP) is one of the most used ways of extracting unique and valuable characteristics from face photos to achieve face recognition; it is also the most efficient and recent algorithm in that research field. [11] Local Binary Pattern (LBP) is a clear yet helpful surface head that names the pixels of an image by thresholding the territory of each pixel and reflects the result as a twofold number. Given its discriminative power and computational straightforwardness, the LBP surface overseer has become a standard methodology in numerous applications. [12] The LBP method first divides the facial image into spatial arrays. Following, inside each array square, a 3×3pixel matrix (p_1......p_8) is mapped across the square. The pixel of this matrix is a threshold with the value of the center pixel (p_0) to yield the binary code. If a neighbor pixel's value is lower than the center pixel value, it is given a zero; else, it is given one. The binary code covers information about the local texture. Finally, for each array square, a histogram of these codes is constructed, and the histograms are concatenated to form the feature vector. The LBP is defined in a matrix of size 3×3, as shown in Equation (1).

$$\text{LBP}=\sum_{p=1}^{8} 2p_s(i_o - i_{p)},\text{with } s(x)=\begin{cases}1 & x \geq 0\\ 0 & x < 0\end{cases} \quad (1)$$

Where i_0 and i_p stand for the intensity value of the center pixel and neighborhood pixels, individually. The acceptance of the LBP arises being that LBP is invariant to monotonic illumination unstable and its robustness to describe as well as capture different local patterns in the image. [12] The algorithm below is the existing pseudocode of LBP. [13]

The Face Recognition Algorithm
Input: Training Image set.
Output: Feature extracted from a face image and compared with center pixel and recognition with unknown face image.

(1) Initialize temp1 = 0 2)
(2) FOR each image I_m in the training set
(3) Initialize the LBP histogram, H = 0
(4) FOR each center pixel i_c in I_m
(5) Compute the gray value of i_c, LBP (1)
(6) Increase the corresponding bit by 1.
(7) END FOR LOOP
(8) Compute the LBP feature for each facial image and combined it into a single vector.

(9) Compare it with the test image in the database.

(10) If it matches its most similar face in the database then successfully recognized.

ii. Residue Number System (RNS)

The residue number system (RNS) is a dispositional number system that allows large portions of figures to be shown as figures in a freethinking bit of trivial length, allowing calculations and parallelisms to progress at a faster rate. [14] RNS is an unweighted figure system that performs arithmetic operations that are carry-free, parallel, higher speed, protected, and fault-tolerant [15]. The Chinese Remainder Theorem (CRT) and Mixed Radix Conversion are the two basic types of RNS (MRC). The large modulus N computations are not required in MRC, which is an alternative to CRT. In comparison to the CRT, which has a computational complexity of order $0(n^3)$ [10], the MRC has a low complexity of 0(n). CRT will be the focus of the proposed research.

iii. Chinese Remainder Theorem (CRT)

The CRT is a consequence of harmony in number theory and its concept within abstract algebra. Chinese Remainder Theorem was first presented in the 3rd and 5th centuries by Chinese mathematician Sun Tzu. CRT is a theorem that is extensively relevant in cryptography. It can frequently be enjoyed to increase the speed of computations. Additionally, it can be employed to build several libraries for the big figures.

iv. Theorem (Chinese Remainder Theorem).

If the integers $n_1, n_2, \ldots, n_k$ are pairwise relatively prime, then the system of simultaneous congruences.

$X \equiv a_1 \bmod n_1$,

$X \equiv a_2 \bmod n_2$,

$X \equiv ak \bmod n_k$.

Has a unique solution modulo $N = n_1, n_2, \ldots n_k$.

$N = n_1 n_2 \ldots n_k$ be the product of every modulus then define:

$$x := \sum_i a_i \frac{N}{n_i}\left[\left(\frac{N}{n_i}\right)^{-1}\right]_{n_i} \quad (2)$$

and this is seen to satisfy the system of congruences by calculation of the example below.

Example: Using the Chinese Remainder Theorem solve

$x \equiv 2 \bmod 7$.

$x \equiv 7 \bmod 9$.

$x \equiv 3 \bmod 4$.

Solution

7, 9 and 4 are mutually coprime, so the Chinese Remainder Theorem guarantees a solution, which is unique mod 7*9*4 = 252,

Here = 7*9*4 = 252;

$N_1 = 252/7 = 36$; $N_2 = 252/9 = 28$ and $N_3 = 252/4 = 63$.

We must solve

$36x_1 \equiv 1 \bmod 7$, $28x_2 \equiv 1 \bmod 9$ and $63x_3 \equiv 1 \bmod 4$.

These simplify to:

$x_1 \equiv 1 \bmod 7$, $x_2 \equiv 1 \bmod 9$ and $x_3 \equiv 1 \bmod 4$.

So, we may take

$x_1 = 1$; $x_2 = 1$ and $x_3 = 3$.

The Chinese Remainder Theorem then tells us that x = 2*36*1+7*28*1+3*63*3 is a simultaneous solution.

Now $x = 72 + 196 + 567 = 835 \equiv 79 \bmod 252$ so, our solution is $x \equiv 79 \bmod 252$.

E. Feature Selection

In machine learning, feature selection is the process of selecting a subset of relevant features for use in model building. Feature selection aims to select a subset of relevant features that are necessary and sufficient to describe the target concept. By reducing the irrelevant and redundant features, feature selection could decrease the dimensionality, reduce the amount of data needed for the learning process, shorten the running time, simplify the structure and/or improve the performance of the learned classifiers. An example of a feature selection technique is the Chicken Swarm Optimization (CSO). [16]

Chicken Swarm Optimization (CSO) algorithm is a nature-inspired algorithm that consists of three main actors the chicks, roosters, and hens based on the fitness value the actor holds its position such as the best fitness value is for the rooster while the worst for the chick. CSO has a set of groups each group consists of one rooster as a leader and two hens, and the rest of the groups are chicks. [17] The unique feature or difference of CSO from other algorithms is the division of the population into three groups named rooster, hen, and chick. The division of the population into three groups increases the utilization rate of the population. Moreover, CSO maintains a good balance between exploration and exploitation as compared to other algorithms. Maintaining a balance between exploration and exploitation of search space greatly influences the performance of Evolutionary Algorithms. Exploration refers to visiting entirely new regions within the search space. [18]

F. Classification.

Support Vector Machine will be adopted for classification in this study**.** The features chosen by the CSO technique will be classified using the Support Vector Machine (SVM). This method will be used to determine the degree of similarity between the test vector and the gallery's reference vectors.

G. Performance Evaluation

The performance of the SVM on both trained and recognized face types will be evaluated based on recognition time. The confusion matrix will be used to determine the value of the performance metrics. The system will be simulated on MATLAB 2016a, and the goal is to investigate the performance of the combination of CSO-LBP and CSO-ELBP techniques based on computation recognition time by comparing the two techniques' outcome results.

III. Results and Discussion

CSO-ELBP is expected to recognize facial images faster than CSO-LBP. As it will be demonstrated, CSO-ELBP is expected to have a lower time complexity than CSO-LBP. This is because incorporating the Chinese Remainder Theorem (CRT) approach into standard LBP will improve the LBP's sequential operation by allowing for parallelism (simultaneous) nonmodular thresholding of the center pixel with adjacent pixels, reducing computation recognition time.

This research is expected to contribute to the body of knowledge by:

1. Formulating and developing an enhanced local binary pattern (ELBP) from the standard local binary pattern (LBP) and Chinese Remainder Theorem (CRT) in other to reduce the computation time of feature extraction.
2. Implement the developed technique of face recognition system in Matrix Laboratory (MATLAB R2016a) Software

The software algorithm to be used is METALAB

2016a on a computer that has an intel 3.4GHZ, Quad-core processor, 4GB RAM, and runs Windows 7, Windows 8, or Windows 10 operating system.

IV. Conclusion.

The study focused on improving the computational processing time of the face recognition system. The expected Enhanced Local Binary Pattern algorithm would demonstrate highly efficient capability in solving computational complexity problems. Oftentimes, geometric/template-based algorithms such as Local Binary Pattern (LBP) had been known for computational complexity during feature extraction. Hence, there is a need to reduce the computational burden by introducing a Chinese remainder theorem method as recommended by the previous authors. With the enhanced Local Binary Pattern algorithm proposed in this paper, it should be able to solve the limitations observed in the standard LBP algorithm and turn to improve the computational processing time performance of the face recognition system.

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