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Facial Recognition by using Local Binary Patterns Histograms (LBPH) using OpenCV in Java SE for a System of Assistance Control

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Abstract: ***The Artificial vision has become very important in the automation world due to its increasing reliability, capacity and rapid return on investment. The purpose of this research is to implement the algorithms necessary to identify a person through his face described through an image captured in real time, using a camcorder, classifying the facial images according to the person who belongs to you. These algorithms have been implemented in a System of Assistance Control (SCA) through facial recognition in the area of administrative services of the municipal government. It has been used the algorithm of Viola Jones [1] to obtain the region of interest: ROI and the local algorithm binary patterns (LBP) to extract the characteristics and the histograms of local binary patterns (LBPH). They are algorithms used for facial recognition, which are based on the local binary operator. The SCA is developed with the facial recognition algorithms ofthe OpenCV library, Offer the user a system trained in a learning machine with the knowledge base obtained from the photos taken of each of the employees in the area.***

Keywords: Facial recognition, OpenCV 3.4.1, Java SE, local binary patterns, LBPH, Euclidean distance

1. Introducción

Facial recognition is a topic in which have focused for years. Computer applications have evolved from the use of simple semi-automatic models in the first years of the 90 's [2]. Face detection is a technique that uses various methods to detect a face in an image or video. Today there are largely devices and websites that use detection technology to identify a face, so the Artificial vision is intended to generate explicit descriptions and meaningful physical objects from data Visuals (images). The human face contains an astonishing amount of information which defines each person, and not all the characteristics are detected in the first instance by the human eye, since they require considerably more time and techniques to be identified.

Human beings perform facial recognition automatically everyday and practically effortlessly. Although it sounds like a very simple task, it has proven to be a complex activity for a computer, because it has many variables that can affect the precision of the methods, such as lighting variation, low resolution and occlusion, among others. Facial recognition is basically the task of recognizing a person according to his face, being an activity more popular in the last two decades due mainly to the new methods developed.

Nowadays automatic recognition of people has many applications thanks to its versatility and efficiency. It has allowed the solution in several tasks such as identifying individuals in public areas, allowing automatic access to some place, providing security for some system or device, recognition of gender, age, emotions and solutions of the Industry, to name a few. Habitually, the recognition is based on techniques of Artificial intelligence, being the most used method the neural networks These have proven to have a good ability to identify people, but are not reliable, therefore, in the present project is used the method of LBPH in sets with the Euclidean distance, what has allowed to be used successfully in fields of Face detection and image classification.

The purpose of the current document is to present a system for facial recognition in a system of assistance control developed with Java SE, which contains OpenCV for the implementation of computer visión, the local binary pattern histogram model (LBPH) is used for this purpose. The proposed system is a novel approach to facial recognition, since the implementations of LBPH de OpenCV have not yet been reported in an application developed in Java se for facial recognition.

LBPH is used to extract characteristics from the database image for each employee that was previously registered in the SCA. This model was chosen because of the assertiveness it has compared to other models [3]. Both the model and the Face Recognition system (SRF) are designed efficiently and are processed completely by the SCA to achieve speed in real time.

The facial recognition algorithm developed in SRF aims to find the characteristics that best describe the image from the facial images already extracted, trimmed, resized and converted to grayscale. The facial recognition system basically operates in the identification of the staff, comparing the input facial image with all the facial images from the dataset to find the employee that matches those features. It is basically a 1xN comparison where N is the number of employees registered in the SCA.
In section 2 This document describes the system specifications and the work scenario. Section 3 explains the use of LBPH in facial recognition in conjunction with Euclidean distance. Section 4 describes the complete implementation of thesystem. Section 5 presents the results

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derived. Finally, section 6 presents the conclusions on the work done.

2. System Specifications and Scenario

Initially, the system specifications were analyzed for optimal decision-making, as part of the design and implementation process. The computer used for SCA and SRF is a digital machine with a processor Intel (R) Core (TM) i5-4200U CPU @ 1.60 GHz 2.30 GHz, 8.00 GB DDR3 RAM and 64bits operating system with Windows 10 Pro. The input peripheral is a Microsoft HD-3000 camera with a maximum video resolution of 1280 x 720 pixels 30pps. Images are processed as 1 × (200 × 200) size arrays, for more convenience in calculations. The faces database is composed of the features already extracted from 2400 images of 30 different people (80 images per person). The system uses LBPH for the extraction of faces and finally, The real-time target translates into 80 frames per second.

2.1. Scenario

The operating scenario of the SCA is located in an area of administrative services of the municipal government. The person in charge of the area specifies the need to have a computer system capable of recording entry and exit of the employees by means of facial recognition.

The proposed software has as a central point to improve and facilitate the registration of assistance, attending at the same time the hygienic condition in the process of checking, Since the staff responsible for cleaning the municipality is in constant contact with organic waste, Inorganic and sanitary. The computer system and equipment are implemented in the main part of the offices where authorized personnel enter. This area has natural light by having windows as can be seen in Figure 1.

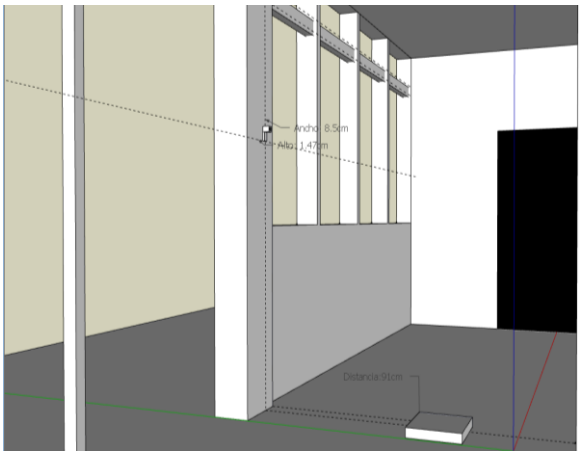

Figure 1: Design of the scenario where the system and equipment are implemented.

3. Facial recognition with OpenCV

3.1 LBPH with OpenCV in Java SE

The LBPH is a histogram that represents the number of occurrences for each binary code for a given image patch, While the LBP was first described in 1994 [4] and refers to the specific binary code it gets when using the LBP operator in a pixel in a grayscale image; As shown in Equation 1:

$$LBP(x_c, y_c) = \sum_{n=0}^{n-1} 2^n s(i_n - i_c)$$

Equation 1. LBP operator.

Using the LBP combined with histograms it is possible to represent the images of the face with a simple data vector. The histograms that are retrieved are commonly used as feature vectors when the classification is done. Then, when using the LBP operator, the histogram of an 8-bit grayscale image describes the occurrence of each of the 256 grayscale values.

In agreement to the size of the image N × M, once obtained from the webcam this is divided into regions. The methodology of local binary patterns has its roots in the 2d texture analysis [5]. The basic idea of local binary patterns is to summarize the local structure in an image by compared each pixel with your neighborhood. Take a pixel as a center or threshold against your neighbors. If the intensity of the central pixel is greater-equal its neighbor, it is denoted by 1 and if no 0, the sign function is defined in Equation 2:

$$s(x) = \begin{cases} 1 & if\ x \geq 0 \\ 0 & else \end{cases}$$

Equation 2. Sign function.

The OpenCV LBPH algorithm uses 4 parameters:

1) Radius: It is used to construct the circular local binary pattern and represents the radius around the central pixel.
2) Neighbors: Corresponds to the number of sample points to construct the circular local binary pattern. Keep in mind, the more sample points you include, the higher the computational cost.
3) X Grid: Represents the number of cells in the horizontal direction
4) Grid Y : Is the number of cells in the vertical direction.

3.2 Person identification

In the proposal developed, the facial recognition process is divided into three steps:

- *Detection and storage:* Detect faces and assign each of them alabel of the person to which they belong and store them in the repository.
- *Recognizer Training:* It consists in reading and training all the images previously stored by each person along with their labels with the recognizer LBPH of OpenCV and the results obtained are stored in the file databaseFaces. yml.
- *Prediction:* An image is introduced to the face recognizer and the prediction is made using the Euclidean distance between vectors (histograms of each image) having as output a prediction of the closest to the image of the face. Figure 2 shows the method implemented in Java SE.

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```
public int reconigze(opencv_core.Mat img){
    // Variable of the ID of the image
    IntPointer label = new IntPointer(1);

    // Variable of the distance
    DoublePointer confidence = new DoublePointer(1);

    // Prediction with Euclidean distance
    lbphFaceRecognizer.predict(img, label, confidence);

    // ID of the image with the closest histogram
    int predictedLabel = label.get(0);

    // Return of the image tag
    return predictedLabel;
}
```

Figure 2: Method in charge of prediction

Each histogram created is used to represent an image of the training data set, So when you enter a new picture you must perform the steps again for it and create a histogram that represents it. To find the smallest difference between distances with respect to the entry, you only need to compare two histograms and return the identifier with the nearest histogram.

4. Implementation

The use of LBPH is followed by the decisions necessary to develop the general model for the proposed system. With respect to the number of regions, the increment leads to a larger size of the vector of characteristics, more calculations for the distance between two vectors of characteristics, but also to a greater precision. Through a set of experiments for different numbers of regions, the size of 8 × 8 was selected because it returns an optimal compensation between the precision and the size of the vector, consequently it gives 16.384 characteristics per image.

However, a model is needed to calculate the distance between the characteristics vectors. For this, a comparison was made between the most popular models: Euclidean distance and distance from Manhattan, observing a similar deviation, but with better performance by the Euclidean distance. Therefore, the Euclidean distance [8] is chosen to calculate the difference between the characteristics vectors, specifically to compare the histograms of the plane's images in grayscale. The necessary calculations were implemented efficiently in the SRF by means of the comparison method developed in Java SE, which is in charge of making the prediction, returning an integer value which is the identifier of the photo of the nearest staff. This process is represented through Equation 3:

$$D = \sqrt{\sum_{i=1}^{n} \left(hist1_i - hist2_i\right)^2}$$

Equation 3. Euclidean distance calculation function.

Where $hist1_i$ and $hist2_i$ are the histograms of the images to compare and D is the value of the Euclidean distance [6, 7]. Figure 3 shows the process for each combination formed between histograms, the Euclidean distance is calculated and as a result of the algorithm the image ID is obtained with the nearest histogram.

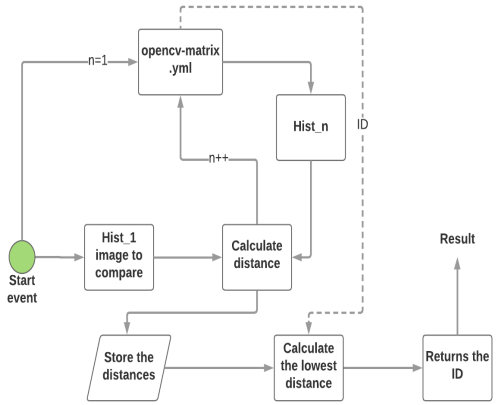

Figure 3: Summary of the distance calculation process.

The algorithm also returns the calculated distance, which is used as a confidence measure. The lower the confidence is better since it means that the distance between the two histograms is closer. However, it is important to note that in order to reliably compare the images must be standardized in size before calculating the distance between the histograms.

5. Results

The development was implemented through OpenCV and Java SE. The database consists of 2400 photos of 30 different people, from which the vector of characteristics and identifier of each person was extracted, storing the data in the file databaseFaces.yml, which is within the developed system. In Figure 4, a sample of the images database of certain people in different positions is presented.

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131-Isaac-2	132-Isaac-20	136-Isaac-9

Figure 4: Sample of 4 people from the database.

The base implemented in its first version is made up of 30 people with 20 photos for 4 different positions which are housed within the SCA. The name of each photo is composed by ID-namePerson-photoNumber. As for the training of the photo database, a time of 46.31 - 47.81 sec was obtained.

The verification test consisted of detecting 30 people to verify the correct prediction of the algorithm of which 3 people were entered without having been registered in the database and without features in the file databaseFaces. yml, The images were obtained in real time, each one of them acquired by means of a camera and lodged in the system temporarily, once it is compared by means of the algorithm of recognition obtained the identifier which got the shortest distance between the histograms of the incoming image and the file .yml. As a result of the verification of the 30 people a classification is made in 3 types: NI is the type of staff that was recognized with their respective ID, NII is the staff that was identified but does not correspond their ID and NIII is the staff that does not have a record in the System.

Table 1: Prediction results

People	*Average distance*	*Classification*
23	58.175 - 62.324	NI
5	69.422 - 93.669	NII
2	107.071 - 115.704	NII

Al concluir la prueba, los resultados de la predicción se presentan en la tabla 1, se puede observar el número de elementos, la distancia y su clasificación, teniendo en cuenta que solo 27 de las 30 personas están registradas en el SCA, it was obtained that 23 of them were detected with an excellent distance of approximation classifying them in NI, that is to say, 85,185% of assertiveness. On the other hand, in the NII classification there are 5 elements of which only 4 are in the system so that the identified personnel that does not correspond to the person has a 14,814% deficiency therefore in the classification NIII you have a 66.67% of personnel without having been registered in the database.

6. Conclusion and Future Works

In conclusion, it can be observed through the results obtained in the tests applied that OpenCV in conjunction with Java SE has a good performance through the algorithms LBPH and Euclidean distance proposed, from the extraction of the characteristics to Identification and detection of the identifier with the shortest distance between the characteristics vectors, which were compared with excellent results with an effectiveness of 85,185%. You still have a margin of error that you can pay attention to in the person who lacks the 3 unregistered. One of the future works is to obtain a greater identification, to improve the precision and thus to surpass the 85,185% with which it counts until this moment the system, as well as to improve the methodology of record of the photos per person. The project has been an improvement and advance in the automation of the process of assistance control, being able to have as another future work its implementation in Web modality.

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