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Developing Viola Jones' algorithm for detecting and tracking a human face in video file

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ABSTRACT

Face detecting and tracking in video clips is very important in many areas of daily life. All institutions, public departments, streets, and large stores use cameras from a security point of view, and detecting and tracking human faces is necessary for indexing and preserving information concerning the visual media. This paper presents a novel method for hybridizing the Viola_Jones face detection algorithm to track and identify a human face in video sequences. The method represents a combination of Viola Jones' algorithm with a measured normalized cross-correlation (NCC) algorithm with a template matching method using the Manhattan distance measure equation in the video between successive sequences After that, the fuzzy logic method is added in comparing the image of the face to be detected with the images of templates taken in the proposed algorithm, which increased the accuracy of the results, which reached 99.3%.

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1. INTRODUCTION

Determining facial area is one of the things of great complexity and difficulty within the fields of computer vision, because the images are of a large size and because people usually undergo some changes to the appearance of their faces, suggestive expressions, lighting, and changing the angle of the face [1], [2]. In the era of information technology and multimedia, digital images and video play a significant role, and the vast amount of data and visual information requires expertise to provide search, detection, indexing, and other items with techniques and equipment [3]. The human face is also one of the most unique features that can be used in the database of images or videos. Wang and Chang [3] because it is considered a strong and distinctive feature of the person to be distinguished or identified, especially in the last few years due to the emergence of infectious diseases and global epidemics that caused the use of devices and techniques for recognition remotely [4].

In 2003, Verma *et al.* used propagating detection probabilities in a video sequence for face detection and tracking [5]. While Eleftheriadis and Jacquin proposed a technique for face location and tracking of video teleconferencing sequences for model-assisted coding at low bit rates [6]. A combination of the tracking system used for enhancement with a static lighting method to determine the face in the video was also suggested by Ku¨blbeck, and Ernst using the changing transformation of the census [7]. An algorithm to track the human front face in the video has also been proposed using dynamic programming iterative (DP) by Liu and Wang [8]. Zhao and others proposed a human counting system in a video focused on face detection and tracking which accomplish face monitoring by integrating a new invariant scale Kalman Kernel-based tracking algorithm filter [9], [10]. Albiolt *et al*. proposed a tool to discover the human face in the video using improvements made to an algorithm that relies on finding homogeneous areas similar to skin in humans [11]. A comparison between the proposed works with all these studied researchin the same field can be viewed in Table 1.

Table 1. Comparison between the proposed work with the all mentioned research

No.	Paper	Year	Algorithm	Data set	Recognition rate	Wrong rate
1	[5]	2003	Prediction and update-tracking	UMIST database	88%	12%
2	[6]	1995	Geometrical method	Live data set	90%	10%
3	[7]	2006	Census transformation	Live data set	90.3%	8%
4	[8]	2000	Templete matching	Live data set	82%	18%
5	[9]	2014	kernel based tracking	Live data set	93%	7%
6	[10]	2011	Normalized color coordinates	Live data set	80%	20%
7	[11]	2000	Skin detection	ViBE video	Good	Not bad
8	Proposed	---	Developing Viola Jones' face detection	Mathlab language database+ Live data set+YouTube	99.3%	0.7%

For the last five years, other ideas are accomplished. The focus on artificial intelligence (AI) algorithms has become noticeable. In particular, the use of neural networks of various kinds and deep learning. One of these studies is the use of the neural aggregation network algorithm [12], convolutional neural networks (CNN), and deep convolutional neural networks, the following is a comparison between these studies and the proposed method as shown in Table 2.

Table 2. Comparision for latest five years in the same region

No.	Paper	Year	Algorithm	Data set	Recognition rate	Wrong rate
1	[12]	2017	Neural aggregation network	IARPA (intelligence advanced research projects activity) Janus Benchmark A (IJB-A)	95.72%	94.38%
2	[13]	2020	Real-time video processing		82%	18%
3	[14]	2017	Convolutional neural Networks	PaSC (point and shoot face recognition challenge), COX (Face), and YouTube	94.96%	6%
4	[15]	2019	Component-wise feature aggregation network	YouTube Faces, IJB-A ((IARPA Janus Benchmark A), and IJB-S (IARPA Janus Surveillance)	96.50%	4.50%
5	[16]	2019	A deep convolutional neural network	Live data set	92.5%	8.5%
6	Proposed	---	Developing Viola Jones' face detection	Mathlab language database+ Live dataset+YouTube	99.3%	0.7%

This research aims to discover an effective method for determining the area of the human face in video sequences by using the important improvements made to Viola Jones' face detection algorithm [17] that determines the facial area in digital images while not allowing the loss of the facial area to occur. This method can be used in many important applications such as browsing the video, identifying the face of people in the videos for crime detection, and indexing the video. A full article usually follows a standard structure: 1. Introduction, 2. Viola Jones' face detection algorithm, 3. Normalized cross-correlation (NCC), 4. Template matching using manhattan distance measure for 2_dimention, 5. Proposed method, 6. Results, and 7. Conclusion.

2. VIOLA JONES' FACE DETECTION ALGORITHM

In 2001 Viola with Jones presented a method for fast and accurate facial identification, where the speed was 15 times faster than any other known technology, with an accuracy of 95% [1], [18]. The method works on what is known as integrated images on the gray image quality so that the face pattern in the image is recognized, the integral image, AdaBoost, as well as the cascade structure, are the three primary concepts that allow it to execute in real time, an integral image is an algorithm for generating the sum of pixel intensities in a given rectangle in an image cost-effectively. It is used for Haar-like characteristics to be easily computed [19] by using the integral rectangle to measure a feature's value, Haar-like consists of (two or more) rectangles, each element of the image contains the sum of all the pixel values in the upper left and this allows a constant time to add all of the regional random rectangles using the "AdaBoost" algorithm, the areas classified as "Weak" are determined, and each of them is considered the sum of the pixels used to compare the rectangular region [20], [21]. AdaBoost has been used as a linear combination of weak classifiers for the construction of strong classifiers, and it reduces redundant features. The algorithm defines a small number of critical and visible properties to produce highly efficient classifiers at high speed. It also contributes to merging the sequential classifiers so that the background of the image is quickly discarded [19]. After calculating the quotient by subtracting the total of white pixels from the total of black pixels, one value is obtained, and this value when it is more in a specific area of the image means that this area belongs to one of the parts of the face [22]. And instead of "AdaBoost" summarizing all the characteristics of the pixels in all regions, it uses the integral image. Then it identifies related and unrelated features. So, a strong classifier is constructed as a linear combination of weak classifiers [1], [2], [22] it is further possible to reduce the number of calculations by cascading, to increase computational efficiency dramatically as well and decrease the false positive rate where it begins to calculate the input window within the first classifier in the cascade. If an error is returned, then this window will end and the detector will return by false, but if it returns the correct one, the window moves to the next classifier in the cascade, and a selection of features is stored in another classifier set in a cascading style and so on, if the window passes through all the classifiers, then the detector returns true. Through this approach, if one classifier lacks to provide the requisite output to the next level, one can discern whether or not it is a face in a quicker time or can reject it [18], [23], Figure 1 shows the method and, examples of Haar characteristics used in the algorithm of Voila-Jones are as seen in Figure 2 [2], [22].

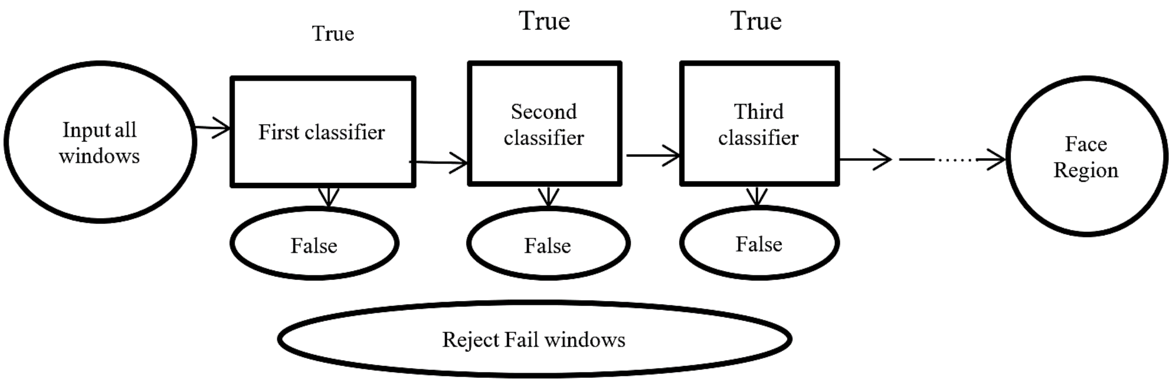

Figure 1. Cascade of the stages (1, 2, 3, 4, ….). The candidate window must succeed in all stages to represent part of the face at the end

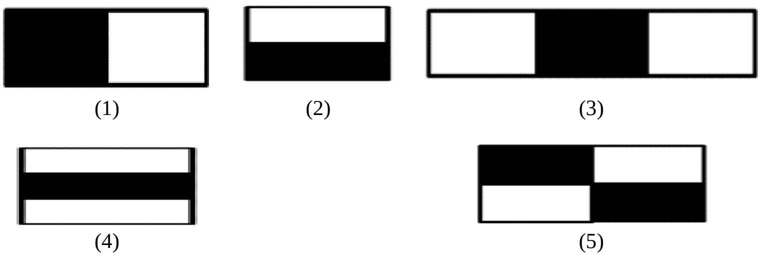

Figure 2. An examples of Haar-like features types used in the Voila-Jones algorithm where feature may indicate from border which lies in between a dark and light region

3. NORMALIZED CROSS-CORRELATION

It is a well-known algorithm, which is the measure of similarity between two groups of features compared with each other, and it is used to measure the extent of similarity between entities of congruence in one image with what they correspond to from entities in another image [24]. The problem of finding two images matching only by matching the points of interest is an important computer vision, and the algorithm NCC is one of the algorithms that is widely used in many techniques and applications that rely on matching parts of those images [25]. The major benefit of neural network convolution (NNC) is that the two comparative images are less sensitive to linear variations in the illumination amplitude, Also the range between -1 and 1 is restricted to it, furthermore, It is much easier to set the detection threshold value and it does not have a simple expression of a frequency domain. It is also unable to directly use fast fourier transform (FFT) in computing NNC, which is more successful with the spectral field, so as the size of the window of the template gets bigger, its computing time increases drastically [26]. The following equation can be used for measuring matches between the element value of template t(i,j) with size a×b with the element f(x,y) of the image with size A×B while template size a×b is smaller than image size A×B [26],

$$NCC(x,y) = \frac{\sum_{i=-a/2}^{\frac{a}{2}} \sum_{j=-b/2}^{\frac{b}{2}} f(x+i,y+j).t(i,j) - a.b.\mu_f.\mu_t}{\left((\sum_{i=-a/2}^{\frac{a}{2}} \sum_{j=-b/2}^{\frac{b}{2}} f^2(x+i,y+j) - a.b.\mu_f^2).(\sum_{i=-a/2}^{\frac{a}{2}} \sum_{j=-b/2}^{\frac{b}{2}} t^2(i,j) - a.b.\mu_f^2) \right)^2} \quad (1)$$

Where all (x,y) ∈ A×B,

$$\mu_f(x,y) = \frac{1}{a.b} \sum_{i=-a/2}^{\frac{a}{2}} \sum_{j=-b/2}^{\frac{b}{2}} f(x+i, y+j) \quad (2)$$

$$\mu_t(x,y) = \frac{1}{a.b} \sum_{i=-a/2}^{\frac{a}{2}} \sum_{j=-b/2}^{\frac{b}{2}} t(i,j) \quad (3)$$

4. TEMPLATE MATCHING USING MANHATTAN DISTANCE MEASURE FOR 2 DIMENTION

The template matching method is very popular and practical and is used in many techniques and applications in identifying different objects, as it gives high accuracy in pattern recognition in addition it does not take a long implementation time compared to other techniques [27]. The manhattan method is the technique that provides the true distance between an image pixel and the theoretical distance is the Manhattan technique of calculating the distance between two points. The distance gives the nearest approximation. By using the Manhattan equation, the distance between the template point and the image window point is determined. Blackmar *et al.* and Jiang *et al.* [28], [29],

$$d(x,y) = \sum |x_i - y_i| \quad (4)$$

5. PROPOSED METHOD

The paper introduces a method for introducing a system for recognizing faces in videos by hybridizing Viola Jones' face recognition algorithm with the algorithm NCC in addition to using the template matching method with the matching equation (Manhattan distance measure for 2_dimentions) to identify the face in each of the used video frames, where these three algorithms were combined so that the faces were identified quickly and efficiently at the same time, also the recognition rate increased by adding fuzzy logic for the recognition system. The work can be summarized in Figure 3.

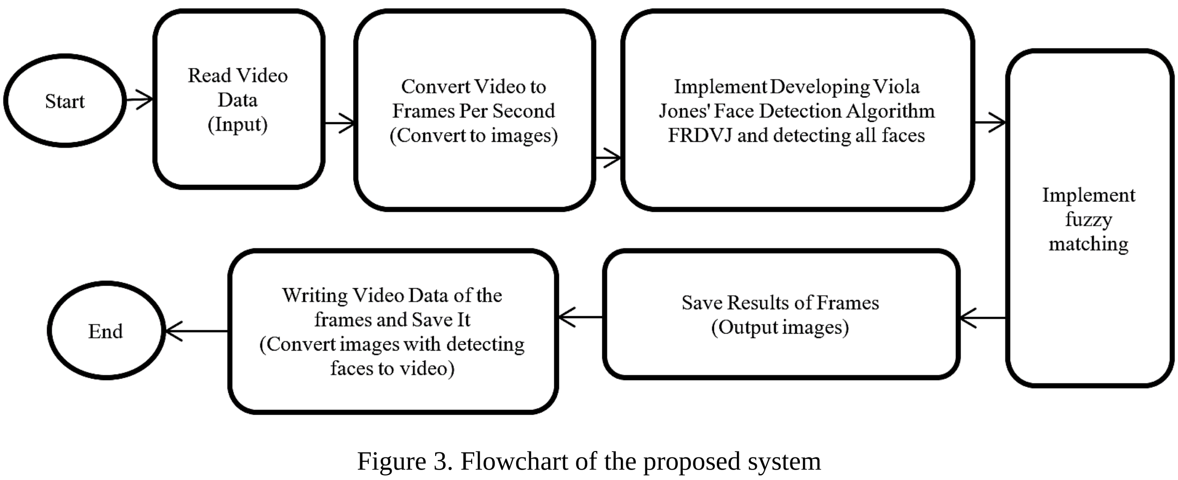

Figure 3. Flowchart of the proposed system

5.1. Pre, post_ processing

The videos used in the proposed research are two types of videos taken from the Mathlab language database for the examples found in the help section, and the other type was captured by a regular mobile camera at different periods. At this stage, a set of processes that precede the process of recognizing the face in the video are carried out, namely: The process of reading the video clip, and splitting the video clip into frames per second. After that, a preliminary treatment process is carried out for each frame separately, which is: the process of converting the frame colors from the red, green and blue (RGB) color system to the gray color system, then changing the size to a uniform size for all frames (images) which is equal to 500×500 pixel. The second part of this stage takes place after the process of applying the developed algorithm for facial recognition to the frames that were initially processed, where in this part a Postprocessing is attached to the frames, which is stored in the results file and converted into a video again and stored in a file of type audio video interleave (AVI).

5.2. Face recognition using developing Viola Jones' face detection algorithm

After the two processes of data collection and preliminary processing that took place on this data in all its stages, the stage of distinguishing and defining the face area begins with each frame. The proposed algorithm face recognition using developing Viola Jones' detection algorithm (FRDVJ) is implemented at this point on the frames extracted from the video clip, where it scans and recognizes the face in the frame. Figure 4 summarizes this algorithm.

```
1. Begin
2. While (max number of frame <> 0)
3. Begin
4. Find the first frame that has a face region by implementing the viola
   jones algorithm and give it value as frame= 1.
5. If frame==1 do
  A. Implement viola jones algorithm.
  B. Crop the face region and save it in the im matrix.
6. Else
   A. Implement viola jones algorithm.
   B. Calculate the number of regions as the face in the count value.
   C. If count=0 then
          1) Implement the NCC algorithm to find High Peak as the face
             region.
          2) Crop the highest peak region.
          3) Implement the Manhattan technique between the face
             template of the previous frame and the current region
             frame.
   D. Else if count >1
          1) Crop all regions that represent a face.
          2) Implement Manhattan technique between face template of the
             previous frame and current regions frame and return
             distances: D1, D2,…Dn
          3) Find max D, and return the face region of it.
   E. End if
   F. End if
   G. Exchange the im matrix with the current face region.
7. End if
8. End while.
9. End.
```

Figure 4. Pseudo code of FRDVJ algorithm

5.3. Modifying suggestion algorithm with fuzzy matching

Fuzzy matching, also known as approximate pattern matching, is a method for finding two text, string, or entry components that are roughly similar but not identical. That is why it was chosen as an intelligent method that depends on guesswork, using inference based on the principle (if_then) rules to increase the power of discrimination depending on reaching the best possible optimal solution as each image is considered to have a similarity with the image of the face to be reached by more than 60% is the image of a face and as shown in Figure 5.

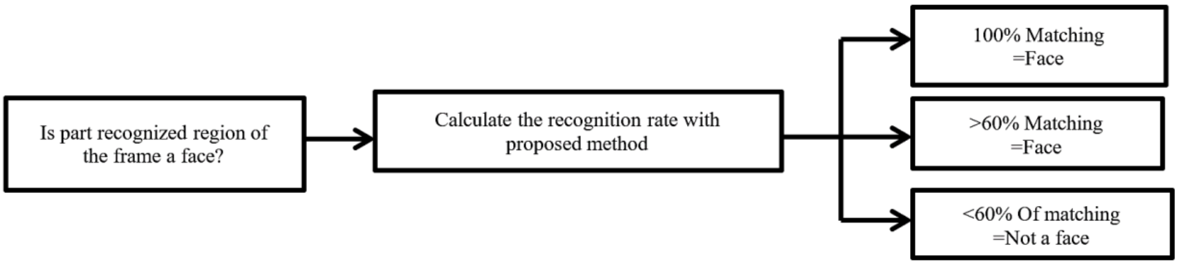

Figure 5. Modifying the proposed algorithm with fuzzy matching

6. RESULTS

After implementing the proposed algorithm on all of the specially designed videos to examine the results of such techniques and from the results of a set of 277 frameworks, note that the results of using the hybrid algorithm FRDVJ, which appear in Table 3, Viola Jones' face identification algorithm gave great results after it was hybridized and combined as in the proposed algorithm spatially because of using Manhattan equation.

Two basic measures were used to determine the results: Right detection rate (RDR) [30], [31] and wrong detection rate (WDR) [30], [32], The results are calculated on the first scale by calculating the number of frames in which the face has been successfully identified to the number of total frames. The higher the value of this measure, the better the method of identifying the face in the frame would be. The equation for this scale can be seen,

$$\text{RDR} = \frac{no.of\ correctly\ detected\ face\ in\ frame}{total\ no.of\ frames} * 100 \tag{5}$$

The second scale is a measure of the algorithm's inability to find and determine the area of the face [4]. Therefore, it represents the ratio of the number of frames in which the face could not be found to the total number of frames. Therefore, the lower the score of this scale, the greater the degree of efficiency of the system in finding areas of the face, the scale equation can be computed [4],

$$\text{WDR} = \frac{no.of\ correctly\ detected\ face\ in\ frame}{total\ no.of\ frames} * 100 \tag{6}$$

Table 3. Results of face recognition in video frames using the proposed method

No.	Video name	No. of frame	No. of frame correct detecting	No. of frame wrong detecting	RDR	WDR
1	Face_ uncomp	31	31	0	100%	0%
2	vipcolorsegmentation	86	86	0	100%	0%
3	visionface	65	63	2	96.9%	3.07%
4	Face_movie1	40	38	2	95%	5%
5	Face_movie2	55	52	3	94.5%	6.5%
6	YouTube movie	30	27	3	90%	10%
Total	6	307	297	10	96.7%	3.3%

After that, the algorithm was modified by adding the possibility of fuzzy logic to it, where the results are tested and as shown in Table 4, where there is increase in the accuracy of the results obtained,and this is shown at the end of the table in the final outcome. A great result obtained after using fuzzy logic in recognized faces, where the discrimination rate reached 99.3% due to the use of the speculative property in the proposed algorithm.

Table 4. Results using fuzzy matching

No.	Video name	No. of frame	No. of frame correct detecting	No. of frame wrong detecting	RDR	WDR
1	Face_ uncomp	31	31	0	100%	0%
2	vipcolorsegmentation	86	86	0	100%	0%
3	visionface	65	64	1	98.5%	1.5%
4	Face_movie1	40	40	0	100%	0%
5	Face_movie2	55	55	0	100%	0%
6	YouTube movie	30	29	1	96.6%	3.4%
Total	5	307	305	2	99.3%	0.7%

7. CONCLUSION

It becomes clear to us how important the resulting combination of the Viola_Jones algorithm and the new algorithm in addition to it matches known templates using the Manhattan equation. As can be seen from the results table of adding the fuzzy logic algorithm and using it in the complementary hybridization of the hybrid algorithm that the recognition and identification of faces in the video clips became more accurate and the results became 99.3% identical. This is because the fuzzy logic brings the result of recognition close to the face without the possibility of error. After all, any part of the face that has been reached by more than 60% is considered the part of the face that is required to be recognized in the video. In the future, it is possible to examine more different video cases with different dimensions from the camera and with other movements, so that the algorithm is better examined and ensured that it can reach the person's face quickly and directly to be exploited in several areas.

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