Face Detection for Color Image Based on MATLAB

Shahad laith abd al_galib, Asma Abdulelah Abdulrahman, Fouad Shaker Tahir Al-azawi

University of Technology, Department of Applied Science, Mathematics and Application of Computer, Baghdad, Iraq.

E-mail: 100243@uotechnology.edu.iq

Abstract. Amazing results in many works in the field of deep convolutional neural networks using them in many fields of machine learning such as image classification control of atrial play, and image annotation. Mathematical analysis of deep convolutional neural networks (CNN) has a broad role in many applications including image classification applications. Face recognition technology has occupied a wide field in research that is still continuing in this work. Face recognition technology is being developed depending on the MATLAB program to develop the subjecting of the color image to the neural convolution network and the work of a program to reduce the time the network deals with the image to reduce the number of layers to only two layers and access the algorithm Suggested in this work. Computer vision of a color image in a face detection study. In this work, the researcher created a fast algorithm to reach the research goal based on new standards in the field of face detection. A new face detection program was designed using MATLAB, CascadeObjectDetector and trainCascadeObjectDetector the face detection devices were developed. In this work, a technique for panning and color image using the convolutional neural network for deep learning is proposed, the method used to reach the goal of this work.

1. Introduction

In recent years, the field of face recognition has taken a wide area of research due to the urgent need for security and commercial applications to demonstrate the interaction between humans and computers using measurement analysis. The work in this field varies greatly in terms of face, skin, gender, and colour [1]. The difference in the background lighting of the face and facial expressions is a reason that increases the complexity of the problem [2]. Among the many applications in the field of face detection, including recognition and monitoring of the driver's face, face recognition by means of video surveillance, or image data management, the algorithms for face detection are characterized by complexity. Face detection is complicated [3]. In [4] which it was clarified that the face detection algorithms are divided into two parts, (i) feature (ii) learning, the first is based on simple facial features without looking at the surrounding light, rotating, or standing. The face position is determined by the vertical projection of the grey level image after the image has been projected for face detection [5]. The role of the neural network appears strongly in the field of facial recognition that has the potential to deal with image data. The neural network technology is multi-layered as it is to design a file containing a recognition system that results in a completely flat structure with inputs that are completely connected to later layers in architecture due to huge interconnecting nodes in addition to the amount of input data that is ignored. This leads to training for all permutations in the input vector.
The fields of science and technology have led us to develop rapidly in order to be able to reach goals that were far from being achieved in the past few decades. Many areas have made life easier, such as machine learning and artificial intelligence, to reach solutions to complex problems in modern science. Computer vision achieves algorithms on the human level in classifying and analysing images. It was presented YOLO theory to discover things and Fast YOLO, which is the fastest detector, is the fastest detector for the general purpose [7]. Face detection was achieved using PCA theory. The network was trained fast [8]. The performance of face detection is evaluated by the false-match rate (FMR), and the false-non-match rate (FNMR) [9]. Viola Jones' method was used to check the number of faces that have been treated and count the number of faces [10]. Modern technology has a role in computer vision at this time when the world is living fighting the emerging corona virus, the disease pandemic (Covid-19) due to technology, work has been completed from home to adapt to the disease [11]. Facial characteristics such as freckles and hair were identified using a new generator to present data on human faces [12], the method Kanade Lucas Tomasi (KLT), which is a simple system where it is able to detect the face and track it where the system is able to detect the face when the head moves and tilts, with Estim Geometric Transform (EGT) function and Duration Geometric Transform (DGT)[13]. In this work, a fast algorithm was proposed based on the use of CNN and the use of the MATLAB program to classify the image and the detection of the face in two stages, the face detection without a mask that has different measurements and criteria for the detection of the face with the mask and the use of the algorithm in tracking objects in these circumstances.

2. Methodology

2.1. Research Design The purpose of this paper is to achieve the recognition of a face or a number of faces, the steps for face recognition will be achieved as shown in figure (1) in this figure a number of steps have been achieved to show the structure of the search.

![Figure 1. Shows the steps of research design with the result](image)

The color image and face highlighting are read as cover layers are incorporated into this work. CNN is used with a mathematical technique to calculate the torsion where the person's face is determined and then the layer is fused as shown in Figure (2).
3. Convolutional neural network method

The convolutional neural network method is unique. It combines segmentation, extraction, and classification in features. One processing unit. CNN components are 7 layers of 4 feature extraction layers and 3 layers of MLP. The feature extraction layer consists of twisting and subsample layers. Warp layer removes noise and detects lines, borders, or corners of an image file. Preventing image distortion is in the Downsampling layer, which reduces image resolution. CNN has built-in stability compared to a typical neural network (MLP). CNN excels at producing high accuracy in the identification process even though the algorithm is complex. In network training, LeNet-5 applies

The proposed algorithm will be built using MATLAB by designing a program for a learning algorithm to identify the face with a simple and easy base to reverse previously identified neural networks to implement a complex database.

4. Mathematical aspects in CNN Technology

Deep learning deals with images using computer vision and processes large numbers of images from multiple countless numbers, Computer vision relies on the convolutional neural network fed into neural networks to reveal the face,

The pictures are inserted in mathematical expressions.

As shown in figure (3), using the filter and multiplying it with the color image, the sum of the product is obtained by the item

The result of this process is a convolution that defines the volume to mathematically represent the image then; the height size denoted by $m_H$, the width of size is $m_W$, the number of channels denoted $m_C$. A color image RGB has three channels $m_3$ red, green, and blue. The filter is $F$.

The filter is single to center each pixel in the filter that must contain the kernel $N$ with the number of channels identical to the image, so a different filter is applied that passes on each channel, Equation (1) calculate the dimensions of the filter

$$\text{dim filter}=(F,F,m_C)$$  \hspace{1cm} (1)

The image is mapped with filter the convolutional process mathematically is

$$\mathcal{C}(I,N)_{x,y} = \sum_{i=1}^{m_H} \sum_{j=1}^{m_W} \sum_{k=1}^{m_C} N_i, j, k I_{x+i-1, y+j-1, k}$$ \hspace{1cm} (2)

$$\text{dim} (\mathcal{C}(I,N)) = \left( \left[ \frac{m_H+2P-F}{S} + 1 \right], \left[ \frac{m_W+2P-F}{S} + 1 \right] \right) \hspace{1cm} S > 0;$$ \hspace{1cm} (3)

If $S = 1$ equation (3) will be

$$ (m_H + 2P - F, m_W + 2P - F)$$ \hspace{1cm} (4)

Where $[n]$ is the floor function of $n$ $P=0$ is the valid CNN output size is equal output size then $P = \frac{F-1}{2}$ is the same CNN, if $F=1$, this means $1 \times 1$ Convolution.
The merging and reduction process distinguishes the image by specifying its information on each channel, which affects the dimensions \((m_H, m_W)\) and maintains the number of channels after passing the filter:

\[
\text{dim}(P(I, N)) = \left(\left\lfloor \frac{m_H + 2P - F}{s} + 1 \right\rfloor, \left\lfloor \frac{m_W + 2P - F}{s} + 1 \right\rfloor, m_C\right) \quad S > 0;
\]

If \(S = 1\) equation (5) will be

\[
(m_H + 2P - F, m_W + 2P - F, m_C)
\]

After the training process, using CNN leads to the reduction of a number of layers Figure (4) shows how a process \(F\) led to the reduction of the three layers.

**Figure 3.** the convolutional neural network in color image

Using filters on the input image using the activation function \(£\),

### 4.1. Mathematical algorithm in convolutional process In 1\(^{\text{st}}\) layer

Input image with \(r^{[1]}, r^{[1-1]}\) and size \((m_H^{[1-1]}, m_W^{[1-1]}, m_C^{[1-1]})\), Padding \(p^{[1]}\), stride \(s^{[1]}\), number of filters \(m_C^{(1)}\) where each \(F^{(m)}\) has the dimension \(f^1, f^1, m_C^{[1-1]}\), and activation function \(£^{[1]}\).

Output \(r^{[1]}\) with size \((m_H^{(1)}, m_W^{(1)}, m_C^{(1)})\) \(\forall m \in [1, 2, ..., m_C^{[1]}]\)

Step1: the convolution step CNN

\[
\text{conv}(r^{[l-1]}, F^{[l-1]})_{x,y} = £^{[l]} \left(\sum_{i=1}^{m_H^{[l-1]}} \sum_{j=1}^{m_W^{[l-1]}} \sum_{k=1}^{m_C^{[l-1]}} F^{(m)}_{i,j,k} \cdot r^{[l-1]}_{i+x-1,j+y-1} + s^{[m]}_{i,j} \right)
\]

\[
\text{dim}\left(\text{conv}(r^{[l-1]}, F^{[m]})\right) = (m_H^{[l]}, m_W^{[l]}, m_C^{[l]})
\]

\[
r^{[l]} = £^{[l]} \left(\text{conv}(r^{[l-1]}, F^{[l-1]}), £^{[1]} \left(\text{conv}(r^{[l-1]}, F^{[2]}), ..., £^{[l]} \left(\text{conv}(r^{[l-1]}, F^{[m_C^{[l]}]})\right)\right)\right)
\]

Where

\[
m_{H/W}^{[l-1]} = \left\lfloor \frac{m_H^{[l-1]} + 2P^{[l]} - f^{[l]}}{s^{[l]}} + 1 \right\rfloor; S > 0
\]

\[
m_{H/W}^{[l-1]} = 2P^{[l]} - f^{[l]}; S = 0
\]

\(m_C^{[l]}\) = number of filters

The learned parameters at the \(l^{\text{th}}\) layer filters with \((f \times f \times m) \times m_C^{[l]}\) parameters

Bias with \((1 \times 1 \times 1) \times m_C^{[l]}\) parameters (broad casting)

Figure (4) and Figure (5) represent the shrinkage of the convolutional layer.
4.2. Fully Connected layer

The definition of a fully connected layer is the layer that enters its vector and then another layer is created from a limited number of neurons.

Then the \( j^{th} \) node with \( l^{th} \) layer the equation is achieved (9)

\[
W_j^{[l]} = \sum_{j=1}^{m_{l-1}^{[l]}} w_j^{[l]} + s_j^{[l]}
\]

\[
r_j^{[l]} = \mathcal{E}^{[l]}(w_j^{[l]})
\]

(9)

The input \( r^{[i-1]} \) might be the result of convolution or a pooling layer with the dimensions \( (m_H^{[i-1]}, m_W^{[i-1]}, m_C^{[i-1]}) \) in order to be able to plug it into the fully connected layer; we flatten the tensor to one dimension vector having the dimension \( (m_H^{[i-1]} \times m_W^{[i-1]} \times m_C^{[i-1]}, 1) \) thus \( m_{i-1} = m_H^{[i-1]} \times m_W^{[i-1]} \times m_C^{[i-1]} \)

The learned parameters at the \( l^{th} \) layer are weights \( w_{j,1} \) with \( m_{l-1} \times m_l \)

Parameters bias with \( m_l \) parameters.

Figure (6) shows the fully connected layer.
Figure 6. Shows the fully connected layer

Figure (7) shows the previous steps that illustrate the chain of operations by which a convolutional neural network is constructed

Figure 7. Shows the steps of convolution neural network CNN

The process is repeated for a certain number of convolutions. The image features are extracted that the entire connected neural network is equipped with the image features followed by the activation functions that aim to reduce $(m_H, m_W, m_C)$ the depth in the network Figure (8) shows the three dimensions of the convolutional neural network

Figure 8. Using the filter and multiplying it with the color image

5. Faces Detection Steps
The identification of a person is done through facial identification, depending on the biological characteristics that the person possesses. This method has many challenges

1. Lighting fixture
When the light source causes brightness, which affects the brightness of the image because the light surrounding the face causes the lack of quality performance to distinguish the face

2. Facial Expressions:
   The person’s feelings are evident in a facial expression that displays messages such as anger represented by frowning by pulling the eyebrows close together, which requires a good algorithm to recognize faces in a variety of expressions

3. Confirmation of Positioning:
   When the person’s face is fixed, it leads to obscuring some of the facial features that he wishes to mask in the image.

4. Partial structural component:
   means partial support, the structural components, including size, color, and shapes such as mustaches, glasses, and beards are considered partial components
   The computer interface deals with the image database to detect the face with its measurements, where the image is recognized, i.e. on the face as a file, in addition to video monitoring. In this work, the Matlab program is used to identify the face
   A fast program is designed to recognize the face of the color image

6. Face recognition using MATLAB
   Face recognition is a complex technology that is most often when unlocking your phone or passing through a high-tech monitoring system. Here comes the question about how to use MATLAB in face recognition?
   The recognition of human faces is carried out using technology in particular, computer vision technology to distinguish facial features taken from photo and video clips. To get the best results, an algorithm was proposed to identify the face and compare it with the face data. By using MATLAB code, face, eyes, nose, and mouth recognition is achieved through the built-in Cascade Object Detector function in the toolbox.

7. Fast facial algorithm
   A program was designed to determine the face, where good results were obtained and in quick steps.
   Figure (9) shows how to use the MATLAB program to identify the face
   The proposed algorithm, with the help of MATLAB, to identify the face, the following steps show the stages of the face detection of the image
   Input color Image
   Step1: analyses image to 3 layers RGB
   Step 2: processed filter $3 \times 3$ After you treat the filter with the image, the image size is reduced
   Step3: In this step, the object properties are determined after Vision, Cascade Object Detector is created
   face Detector = vision. Cascade Object Detector ();
   step4: In this step, you call the object with the arguments (as if it behaves as a function).
   Space5: Facial information is identified and read
   Location of the Face = step (face Detector, the Image);
   output the image with face detected
8. Discuss the results

In this section, the results obtained for the correct rate of face detection are presented. The new algorithm shows its efficiency by presenting the results obtained. In this work, a modern version of MATLAB was used to design a face detection program for several people in one image, and the best results were obtained. Figure (10) and Figure (11) show the efficiency of the proposed algorithm to detect the face of a number of people and distinguish their faces with the label. The correct rate of the proposed algorithm is 98%, an image containing 3 members and the image is (432 × 980 × 3 unit8) with Boxing Faces is and table (1) shows Bounding Box values which comprises of [x, y, Height, Width] of faces to be detected Figure (10) The sample to which the proposed algorithm is applied

Table (1) shows Bounding Box values

| X   | Y   | width | Height |
|-----|-----|-------|--------|
| 442 | 150 | 115   | 115    |
| 125 | 28  | 150   | 150    |
| 571 | 31  | 267   | 267    |
Figure (11) shows the efficiency of the proposed algorithm to detect the face of a number of masked people and distinguish their faces.

9. Conclusion
In this paper, a new algorithm was built for face detection technology by segmenting the color image into RGB in which a neural network is used, where the face area of a person was detected through a comparison between the input and output image, the correctness of the face detection rate 98%.

With the implementation of the algorithm in the MATLAB program, good results were obtained for the indications of the algorithm.

a new technique for identifying the face of color images was presented after analyzing the image and dividing it into three layers resulting from the neural network that helps to detect the features of the face, and by using the MATLAB program, a classification technique is applied to detect the face, which satisfactory results were obtained after using the basic equations.

The algorithm was applied to the images without a mask, and the other stage was with the mask. As for the last, the experiment was on the image with the mask and glasses, and the algorithm was applied with high and fast technology, as the algorithm proved its efficiency because the examples showed that the new algorithm is valid under the new circumstances.

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