Al-Furat Journal of Innovations in Management Sciences

ATU- AFJIMS, Volume: 5, March 2026
ISSN : 3106-4973

The Face Detection Based on RGB Color Model and Morphology Operation

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Abstract. *Face detection has garnered a lot of attention and has been studied quickly in a large number of possible computer and communication applications, including automatic access control. Also, face detection is one of the most important aspects of face recognition as a preliminary step. Face detection is challenging due to the large number of variations in the appearance of the image, i.e., contrasting mode, clogging, image orientation, lighting condition, etc.*

In this paper, we present an effective algorithm using RGB and the color model's morphological processing to detect human faces on color images. Tested on 170 various images obtained from the internet, the proposed algorithm proved highly effective with reduced computation time. The face detector in this study test applied 71 images with 100% accuracy; it works best when the image contains group photos with a small face region.

Keywords: *Face detection, Color, Skin detection, Image processing, Skin color.*

1. INTRODUCTION

Face detection has evolved over the years along a variety of methodological orientations. Early approaches fell into four broad categories: knowledge-based, feature-based, template-matching, and appearance-based approaches. Knowledge-based approaches differ from the others in that they are founded upon intuitive, rule-based representations of facial structure—i.e., geometric configuration of eyes, nose, and mouth, and the interfacial spatial relationships likely to occur. Rather than learning from data, these methods hand-code human-interpretable rules regarding what a "normal" face might appear to be, and thus are interpretable but are brittle in unconstrained environments[1]. Face detection approaches have traditionally been grouped into a variety of paradigms. Of these, characteristic-based methods draw upon low-level appearance information that is intrinsically correlated with face appearance. These include color-based features—i.e., more precisely, skin color models—and local structural descriptors that characterize texture and edge patterns. These features are resistant to plausible pose and illumination changes. For example, Wang et al. [2]

Al-Furat Journal of Innovations in Management Sciences

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ISSN : 3106-4973

While modern face detectors are primarily driven by deep neural networks, traditional approaches used to employ handcrafted visual features—skin color, texture, and structure—to find faces efficiently. Such solutions typically modeled skin color as a probabilistic region in the color space and combined it with structural descriptions (e.g., edges, local binary patterns, or census-like transforms) to make them more invariant under lighting and pose changes. For instance, face regions are generally demarcated by the spatial layout of prominent features like the eyebrows, nose, mouth, and eyes, and skin-color segmentation to mark probable candidates for faces against the background. Although such mixture methods enabled real-time processing in constrained settings, they remain susceptible to intricate backgrounds and uneven illumination—shortcomings prompting the shift towards data-driven deep neural networks in more recent years [3-4].

This paper introduces a fast algorithm for the detection of human faces in RGB color images and morphological operation in the color model and applied the algorithm to 170 diverse images collected online and found it to be very satisfactory with reduced processing time

This paper is organized in the following format: Section 2 provides explanations on the suggested skin color region classifier. Section 3 provides the face detector in brief form. Section 4 provides the experimental demonstration of the proposed algorithm. Section 5 provides the conclusion of this work.2. Background theoretical

2. MATERIALS AND METHODS

2.1. MATERIALS

2.1 .1 Median filter

The median filter is a non-linear filtering algorithm based on order-statistic, which replaces the faulty pixel value with the median of nearby pixel values. As it performs well in preserving edges and effectively removing salt-and-pepper noise, even today it remains one of the most widely used denoising algorithms in image processing.

These filters are derived based on as particular type of image statistics known as order statistics. Usually, these filters work on small sub image, "Window", and substitute the center pixel value (just like convolution process).Order statistics is a method that puts the whole pixel in sequential order, assuming an NXN window (W) the pixel values can be arranged from smallest to largest.

observed that noise values that are extremely large or extremely small will either end up at the top or bottom of the sorted list. As a result, the median will typically swap out a noisy value for one that is more in line with its surroundings [5].

2.1.2 Color Segmentation:

While contemporary deep learning-based face detectors primarily use learnt hierarchical features instead of handcrafted combatants, skin colour could still serve as a useful prior in some contexts, especially when designing on resource-constrained systems or as an intermediate stage to reduce search space. Skin colours of humans, over ethnic groups, form a very distinct and limited part in chrominance representations as the HSV or YCbCr, which is focused on human perception. Other-skin Areas can be successfully suppressed by projecting the input image into such colors spaces and through an adaptive threshold, allowing subsequent candidate detection stages to concentrate on plausible face candidates. This tactic is especially effective under controlled circumstances or when paired with deep models as a region proposal filter [6].

Al-Furat Journal of Innovations in Management Sciences

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2. 1.3 Color space selection
For skin color detection at each pixel, the t skin and t non-skin threshold values are decided based on the available colour components. Skin color was detected within a window around the mean of Cb and Cr.
In addition the varying color spacing discussion will is be presented to identify optimal for and /or application,, however three other the system, where it investigated HSV and YCrCb spaces [7]. Alternative colour spaces, such as HSV and YCbCr, are often more effective than RGB for skin-color segmentation in face identification, owing to their ability to distinguish chrominance (colour) from luminance. In the HSV colour space, the Hue (H) and Saturation (S) components provide strong cues for identifying skin tones because they are relatively invariant to lighting variations and closely align with human colour perception; empirical studies have identified specific H-S ranges that reliably correspond to human skin [Khan et al., 2021]. Similarly, the YCbCr space uses the Cb and Cr chrominance channels to effectively segregate skin regions, with fixed thresholds in these channels resulting in excellent segmentation accuracy by suppressing non-skin areas [Almohammadi & Almogren, 2022]. In contrast, the RGB model combines intensity and colour information, is device dependent, and lacks perceptual uniformity, making it unsuitable for direct skin detection without first transforming into a more discriminative colour space [Khan et al., 2021].

2.2. METHODS

2.2.1 Morphological Image Processing
"Mathematical morphology offers a powerful collection of techniques for analysing and representing shapes in binary and greyscale images. Core morphological procedures such as dilation, erosion, opening, and closing are commonly used in both preprocessing and postprocessing stages to improve object structures, reduce noise, and refine boundaries. Dilation, for example, expands foreground regions by reflecting a structuring element over object boundaries, effectively increasing object size by roughly half the structuring element's diameter. When intensity-based methods fail, morphological techniques enable shape-driven object recognition by transforming greyscale images into binary form—particularly in cases where item identity is better described by geometric attributes than pixel values alone [8].
And erosion reduces the size of stuff. The objects are smaller than the structural element, measuring half its size. If A is a rectangular object in the image and B is a structural element, the yellow region indicates how much A has fallen in size due to the erosion process. The opening operation is erosion followed by dilation, while the closure operation is erosion followed by dilation.
The four basic morphological operations for binary image processing as seen in Figure 1 (b), making items larger. The items are larger, measuring half the size of the structural element. Figure 2 (a) reduces the size of items described by their shape in the structuring element. The objects are smaller, measuring half the size of the structural element. Figures 2 (a) and (b) depict the two derivational operations of erosion and dilation. Opening is described as erosion followed by dilation, while closing is dilation followed by erosion.

2.2.2 Remove noise

The open procedure begins with erosion and then dilation; the end result is a smooth picture contour, the elimination of the image edge, and the cutting off of the narrow valley. As seen in Equation 1.

$$A \circ B = A \cup \{(B)_z | (B)_z \subseteq A\} \qquad \text{Eq.(1)}$$

The close procedure begins with dilation and then with erosion it can also smooth the image's edge, fill small holds in the image, and link nearby objects. In contrast to the open operation, it can often integrate thin gaps, remove small holes, and fill gaps on the contour [9].

2.2.3 Binary image

Digital images can be classified into three types: binary, greyscale, and colour as illustrated at Figure 3. A binary image is the simplest type, with each pixel taking only one of two potential values—typically 0 (black) or 1 (white). This stark representation is extremely useful in applications that require form analysis, object detection, or pattern recognition, such as industrial inspection, document scanning, and medical imaging (for example, segmentation of blood arteries or tumours). Despite its simplicity, binary imagery forms a solid foundation for morphological operations and feature extraction in computer vision pipelines [10].

3. RESULTS AND DISCUSSION

3.1. RESULTS

3.1.1 Enhancement

Face image enhancement means removal the noise of image by applying of a median filter with window (3*3).

Algorithm (1) : Enhancement Steps
Input: face image
Output: Enhancement Image
- applying of a median filter with window (3*3) for reduce noise of image

3.1.2 Skin color modeling segmentation

This study prioritises computing economy and accuracy when creating a skin colour detector as a preliminary filter for rapid facial recognition. The methodology avoids sophisticated algorithms in favour of a simple but effective paradigm. This model is built on a defined colour scope that was produced through statistical analysis of ground-truthed skin pixel data in the RGB colour space, allowing for exact segmentation of skin regions.

3.1.3 Morphology processing

In the skin Pixels other than those within the skin colour region were eliminated during the modelling and segmentation process, with the exception of skin colour pixels across the image. Because a segment image contains a lot of noise and interference, such pixels will be eliminated using a morphological treatment as part of the skin colour region classification procedure. First, portions smaller than the structural element matrix are removed during the erosion process. The current regions are then reduced in size, eliminating the need to remove minor areas. As a result, the shrunk areas are increased to avoid abandoning skin colour regions by removing portions smaller than a face.

Labelling connection elements and rejecting non-face areas. The connection element labelling is necessary in the binary image of the region obtained in order to recognise connected pixels as one space. Because it still has a background, hands, arms, legs, and clothes that are comparable to those of a flesh colour region, non-face region candidates are rejected. Thus, in the connected element labelling, areas that cannot be statistically classified as face areas are deleted in the following manner.

3.1.4 Removal of areas smaller than 24 × 24

In this study, the skin colour region classifier is employed as a preliminary step to improve the speed of face detection through the learning process, not to confirm the location or presence of a face. The face detector removes areas smaller than 24 x 24, the minimum size for a face based on face learng data.

Algorithm (2): This work is based on RGB color model
Step1:Resize the image to fit a 256x256 pixel template. Step2:Convolve RGB to red image , green image, and blue image . Step 3: Using Sobel operators on RGB image to find the edge map image. Step 4: If the R,G and B values of the color histogram > skin threshold and edge values < edge threshold, then the skin is skin pixel otherwise it is non skin pixel. Step5: Consider pixels with in the threshold range faces. Step6:Thresholdrangeisreducedtoapresetlowerlimit.Thenapplyanotherstateofconvolutionprocesstothenextstepifthelowerlimitisreached. Step 7: Use 8- connected neighbors to find the different regions. Step 6: Find for each region, the height, the width and the centroid and also the percentage of skin in each region. Step 8: apply morphology operation erosion and dilation for remove noise from image Step9:the multiply the result of step 8 with original image

3.2. DISCUSSION

To demonstrate the performance of the method described in this paper, a test was performed on 170 photos collected online using Matlab 2015, with the main window of the proposed system depicted in Figure 7. This has five commands and nine pictures. These commands are: load images, median filter, RGB colour, convert to binary, face detection, exit, and the first step, read image, as illustrated in figure (4).

The figure (5) shows reading the image and display in picture box, and resize image to stander size image 256*256.

this paper applies the median filter with window [3 3] for enhancement the image colour image (R band, G band, B band) and reduce noise as shown in figure (6). RGB colour detection in an image is used to detect a particular RGB colour spread or the particular RGB colour pixel throughout a given image. This process is beneficial in lot of aspects of image processing. Here, in

Al-Furat Journal of Innovations in Management Sciences

ATU- AFJIMS, Volume: 5, March 2026
ISSN : 3106-4973

our paper, RGB colour segmentation can be used to apply in order to separate skin colour form an image by figuring out the skin colour values or components a shown in figure (7).
Skin segmentation seeks to identify skin regions within a still input image. Skin modelling simulates the distributions of skin and non-skin colour pixels in a picture.We define two functions: histogram(i,j) for the colour space values received from our Skin Model's RGB histogram plot, and skin colour threshold(i,j) for the skin colour threshold produced by the model. Similar to previous experiments, we collected real-time data in the form of our own photographs and performed a face detection algorithm on them. The results were examined, and inaccuracies were identified. To test the adaptability of our system, various image types were used as inputs and simulated in MATLAB for face detection. A single face image was captured and simulated in MATLAB, and the mistakes were documented. Figure 8 shows how the entire process was documented.
Then apply morphology operation erosion and dilation for remove noise from image , the multiply the result in original image as shown in figure (9)

4. CONCLUSIONS

This study was effective in creating a hybrid face detection model that combines the computational economy of a skin-color classifier with the robust accuracy of an appearance-based algorithm. By incorporating an initial skin-color filtering stage, the suggested approach efficiently eliminates a major part of non-face regions, streamlining future processing and increasing overall computational efficiency. Empirical results on a 170-image dataset show 100% accuracy, confirming the model's great efficacy, especially in complicated settings like group shots with small face regions. This integrated method offers a realistic solution for achieving a better balance of detection accuracy and operational speed in actual applications.

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ATU- AFJIMS, Volume: 5, March 2026
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Figure and tables

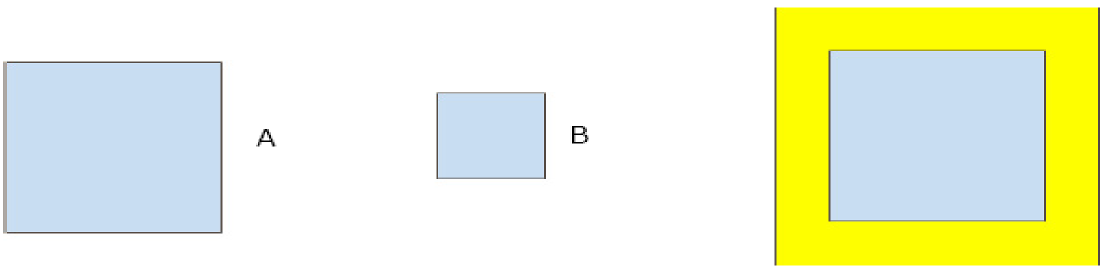

Fig. 1. Dilation process

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ATU- AFJIMS, Volume: 5, March 2026
ISSN : 3106-4973

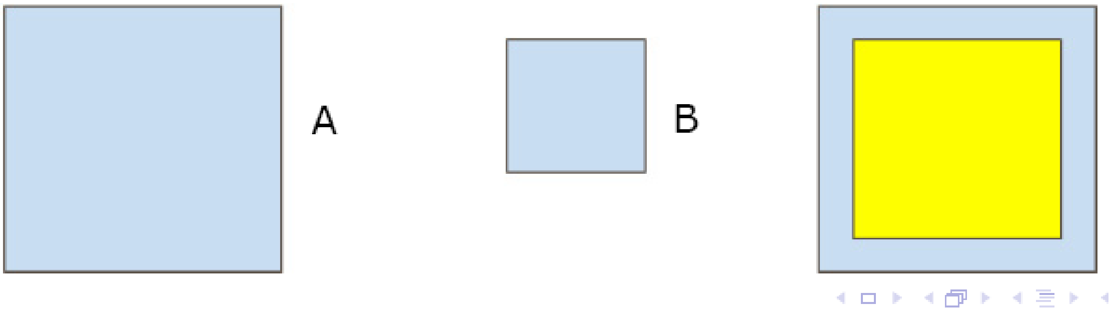

Fig.2. Erosion process

(a) Original image **(b) Gray scale image** **(c) Binary image**

Fig.3. Pictures in different model

Fig.4. Main windows

Fig.5. Read and resize image

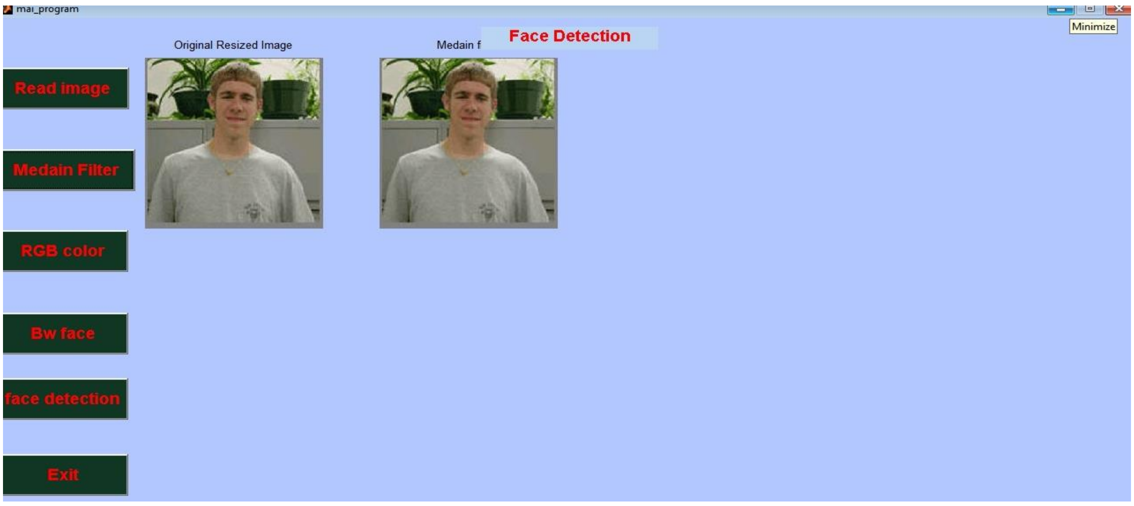

Fig.6. enhancement the image by median filter

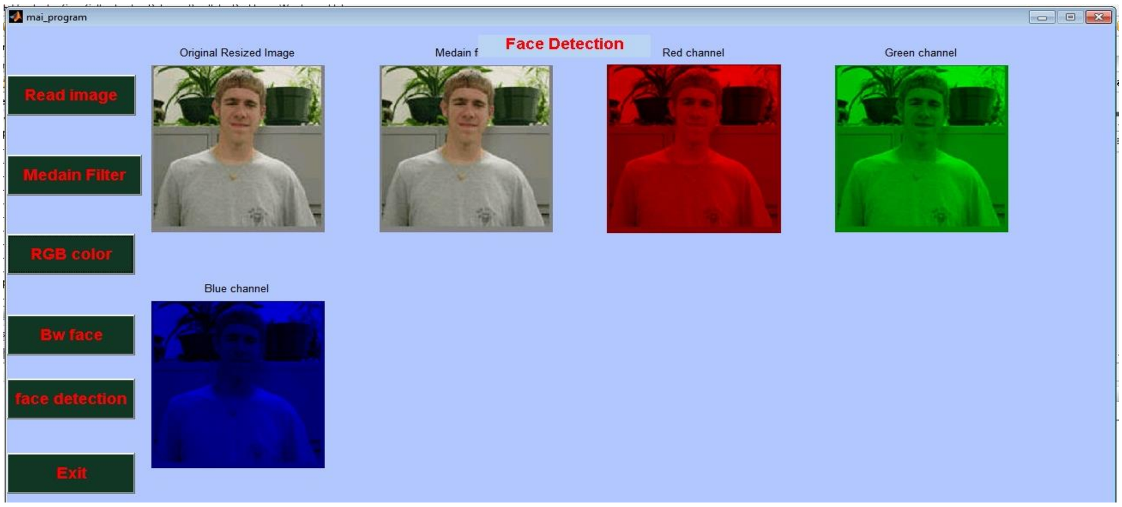

Fig.7. show RGB of image

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ATU- AFJIMS, Volume: 5, March 2026
ISSN : 3106-4973

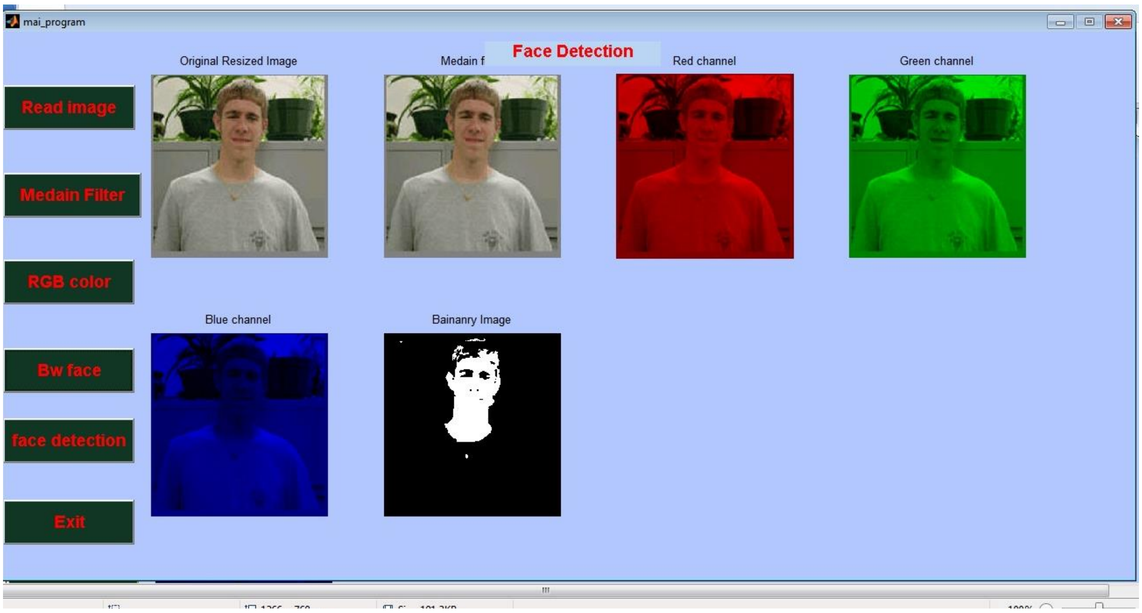

Fig.8. face detection in binary colour

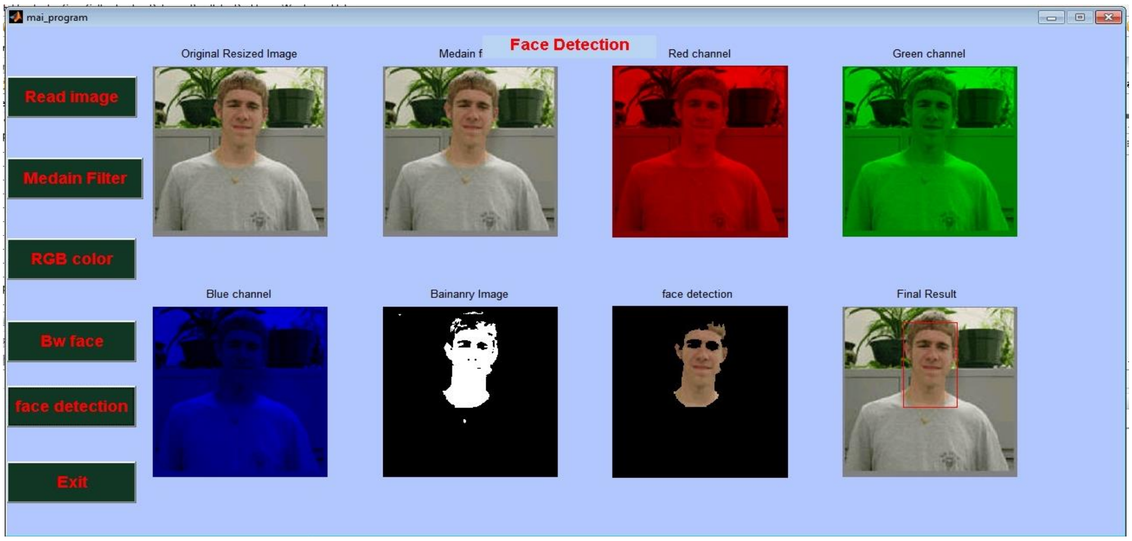

Fig.9. Final face detection

