# Partial Face Recognition Using Phase Only Correlation (POC)

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*Abstract*— **Numerous methods have been developed for holistic face recognition with impressive performance. But Partial faces frequently appear in unconstrained scenarios, with images captured by surveillance cameras or handheld devices (e.g., mobile phones) in particular. In this paper, a method for automatically recognizing partial human face images is presented. The technique uses the Phase-Only Correlation (POC) for image matching. Experiment was conducted on a database of 479 images of 40 different persons. For experimental evaluation, a mask was generated on every query image to identify and separate the non-occluded portions. These separated portions were compared with the gallery images using the POC technique. Results have shown the proposed method is practical and provides preferable performance.**

***Keywords—Partial face; occlusion; phase only correlation.***

## I. Introduction

Face Recognition is the technique to verify whether the entered image or input is exactly similar to the available images present in the databases. There are some parts of human face which has its unique identity like Nose Structure, Eyes, and other Facial Parts etc. Considering these parameters, we can easily determine whether these objects are the part of given Human Face or not.

Face recognition (FR) has received substantial attention over the last three decades due to its value both in understanding how Face Recognition process works in humans as well as in addressing many challenging real world applications.

The performance of automatic Face Recognition systems has advanced significantly. While face recognition in controlled conditions has already achieved impressive performance there still exist many challenges for face recognition in uncontrolled environments.

Such scenarios include:

- Occlusions
- Facial Accessories
- Limited field of view
- Extreme Illumination

Typical applications of face recognition in uncontrolled environments include recognition of individuals in video surveillance frames and images captured by handheld devices (e.g., mobile phones), where a face may be captured in an arbitrary pose without user cooperation and knowledge. In such scenarios, it is quite likely that the captured image contains only a partial face. Table-1[26] lists a categorization of partial face images.

Commercial off-the-shelf (COTS) face recognition systems are not able to handle the general PFR problem since they need to align faces by facial landmarks that may be occluded. Law enforcement agencies are also in urgent need of a system capable of recognizing partial faces. First, a PFR system will enable them to identify a suspect in a crowd by matching a partial face captured by, say, a mobile phone to a watch list through a wireless link in real time. Second, given a photo of a certain unlawful event, PFR is needed to recognize the identity of a suspect based on a partial face. We call the resulting problem a Partial Face Recognition (PFR) problem, so as to differentiate it from the holistic face recognition problem.

## II. LITERATURE REVIEW

Some various popular face alignment methods include the Active Shape Model (ASM) [1] and the Active Appearance Model (AAM) [2], which depend on localizing a certain fixed number (typically 68) of landmarks on holistic face.

Yang et al. [3] and Yi et al. [4] proposed an automatic partial face alignment and matching approach, for partial faces resulting from a limited field of view. But, their approach requires high-resolution images (with an inter pupil distance of more than 128 pixels) with good skin texture, but it is not applied to pose variations.

Non-frontal face recognition has also attracted significant attention by multi-view [5], [6] and cross-view [7], [8], [9], [10], [11], [12] face recognition. In case of cross-view FR, most approaches apply 2D or 3D appearance models to synthesize face images in specific views. Multi-view face recognition requires that the gallery contain a large number of poses for the corresponding subject which is not practically possible to satisfy in practice. In these approaches, a critical

TABLE 1
A Categorization of Partial Face Images

| **Scenario** | External occlusion | Self occlusion | Facial accessories | Limited field of view (FOV) | Extreme illumination | Sensor saturation |
|---|---|---|---|---|---|---|
| **Examples** | occlusion by other objects | non-frontal pose | hat, sunglasses, scarf, mask | partially out of camera's FOV | gloomy or highlighted facial area | underexposure or overexposure |
| **Image** |  |  |  |  |  |  |

step is to localize a certain fixed number of representative facial landmarks and establish correspondences between two images in different views accordingly. Due to this, the images are expected to have visible anchor points irrespective of the view.

A general approach of partial face recognition method is based on Multi-Key point Descriptors (MKD) which is the method that does not require face alignment by eye coordinates or any other fiducial points. The invariant shape adaptation makes image matching more robust to viewpoint changes which are desired in face recognition with pose variations.

Some FR approaches only require face sub images as input, such as eye , nose [13], one half (left or right portion) of the face [14], or the periocular region [15]. Again, these methods require the presence of certain facial components and pre alignment.

Instead of holistic representation, some face recognition approaches have adopted parts-based representations to deal with occlusion and pose variations. A simple way is to divide the aligned face image into several sub regions [16], [17], [18], [19], match each sub region, and then fuse the matching results. Alternatively, one could detect several predefined components (such as eye, nose, and mouth), and then recognize the face by fusing the matching results for the components [20], [21], [22].

## III. Proposed Method

In this paper we present a solution to the partial face recognition problem. Gueham et al. [25] developed an algorithm for the automatic recognition of partial shoeprints. Their method used the POC approach combined with spectral weighing function to develop a function named as Modified POC (MPOC). The peak value of the MPOC function was considered as the similarity measure for image matching. Similar images produced a distinct sharp peak, while dissimilar images showed a significant drop in the peak.

The proposed work uses the concept of POC technique for the comparison of the partial face image (query image) with the gallery images.

This approach performs the following steps in response to a query image: 1. Mask Generation based on the occluded portions of the query image 2. The generated mask imposing on the query and gallery images, and extraction of the non mask (un-occluded) area. 3. Comparison of the non-occluded parts so obtained using POC and arriving at possible image matches.

Each of the above mentioned steps are described briefly in the following subsections.

### *A. Mask Generation based on the occluded portions of the query image*

In this subsection the occluded mask generation steps are explained in detail.

1. The query image is converted to binary image (Otsu method) followed by the application of morphological operation.
2. A search is carried on the image thus obtained, to locate the rows having a concentration of black pixels above a specific threshold. The threshold value is specified as 55%.The constituent pixel values of these rows are set to zero.
3. If the rows located in previous step are consecutive in nature then these rows are to be considered for the mask. To determine the consecutiveness, the following steps are performed:

   3.1. The image obtained after step-2 is again searched to count continuous rows constituting of only black pixels.

   3.2. If the count exceeds 25 then the corresponding set of rows are specified as a mask.

### *B. Mask Imposition:*

The mask obtained is imposed on the query as well as the gallery images and the non mask area(s) are excluded from both the query and gallery images. Comparisons are performed with the non mask parts of the images thus obtained.

### *C. Comparison using POC:*

Before going to use patch wise POC calculation and comparison of query and gallery images, we introduce a brief idea of POC.

#### *1) Phase only correlation (POC)*

In the Fourier domain, the phase information is much more important than the magnitude in preserving the features of image patterns, as proved by Oppenheim et al [23].

Consider two images $g_1(x,y)$ and $g_2(x,y)$. The Fourier transform of $g_1$ and $g_2$ are $G_1(u,v)=A(u,v)e^{j\varphi(u,v)}$ and $G_2(u,v)=B(u,v)e^{j\theta(u,v)}$, where $A(u,v)$ and $B(u,v)$ are amplitude spectral functions while $\varphi(u,v)$ and $\theta(u,v)$ are phase spectral functions, respectively. The phase-only correlation function $q_{g_1g_2}(x,y)$ of the two images $g_1$ and $g_2$ is defined as:

$$q_{g_1g_2}(x,y) \quad F^{-1}\left\{\frac{G_1(u,v)G_2^{*}(u,v)}{\left|G_1(u,v)G_2^{*}(u,v)\right|}\right\}$$

$$=F^{-1}\left\{e^{j(\phi(u,v)-\theta(u,v))}\right\} \qquad (1)$$

where $F^{-1}$ denotes the inverse Fourier transform and $G_2{}^*$ is the complex conjugate of $G_2$ .

The term $Q_{g_1g_2}(u,v) \quad e^{j(\varphi(u,v)-\theta(u,v))}$ is called the cross-phase spectrum between $g_1$ and $g_2$ [24].

If the two images $g_1$ and $g_2$ are identical, their POC function will be a Dirac δ-function centered at the origin and having the peak value=1 as shown in the fig.1 below.

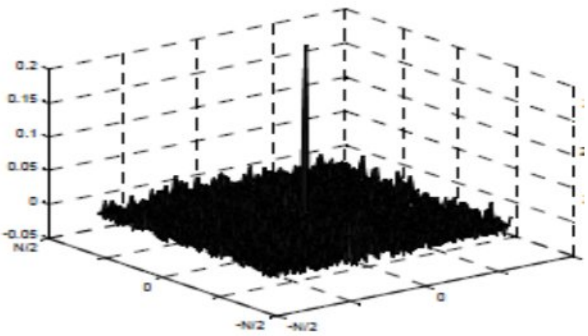


Figure. 1. POC peak value at the center.

*2) Image comparison using POC*

As stated in previous section, in the Fourier domain, the phase information is much more important than the magnitude in preserving the features of image patterns. So, this step requires the phase information to be extracted for comparing the corresponding, already extracted, non mask areas of the query and gallery images for finding similarity.

Here an elaborate processing is done so as to increase accuracy. The processing involves the following steps:

1. The extracted non mask image parts (of both query and gallery) obtained in mask generation step are divided into smaller blocks of size 15*15.

   Let q = smaller block of non mask part of query image and g= smaller block of non mask part of gallery image corresponding to q. A smaller block pair (q, g) undergoes the following operations:

   1.1. Canny Edge Detection is applied.

   1.2. 2D-Discrete Fourier Transform is obtained and the phase information is extracted.

   1.3.The phase information is applied in the POC function:

   $$Q_{qg}(x,y) \quad F^{-1}\left\{e^{j(\phi(u,v)-\theta(u,v))}\right\}$$

   to obtain the POC value between smaller block q and g.

2. The POC value for each of the extracted non mask parts of the images is obtained by adding the POC value for its constituent smaller block pairs. This value is named as ‘Total-POC’.

3. The ‘Total-POC’ values for each of the corresponding non mask parts of the query and gallery image is again added to obtain a ‘final-POC’ value. The ‘final-POC’ is ultimately used for the identifying the correct match between the specified query image and the images of the gallery set.

According to subsection C.1, it is assumed that the evaluated value of ‘final-POC’ will be highest for the correct recognition of the query and gallery image.

Fig.2. shows the pictorial representation of the proposed approach.

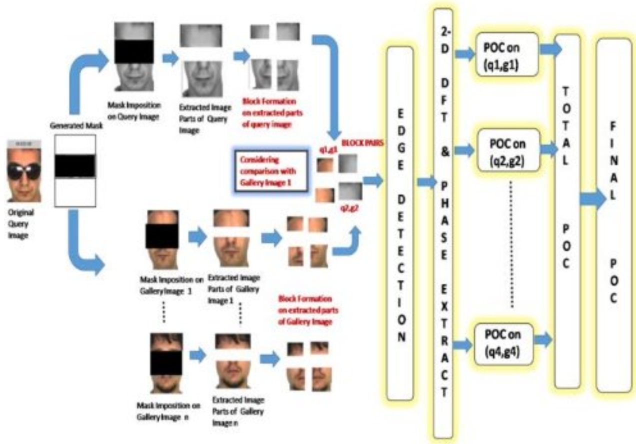


Figure. 2. Step by step representation of the proposed method.

## IV. Experimental Result

We have tested the proposed POC based method on AR face database. The Query set contains occluded facial images of 40 subjects, with some wearing only sunglasses or only scarf or both scarf and spectacle along with having left or right side illumination. For every subject approximately 12 different occluded faces are included in the query set thus making the set to contain a total of 479 images. The Gallery set contains non-occluded facial images of 40 subjects (one image/subject) with neutral expression. It contains a total of 40 images. The images contained in the two sets are cropped to a size of 165*120 pixels. The performance of the proposed method is evaluated based upon the two databases.

In the experiment, for each test image from the query set, 40 such 'final-POC' values are obtained, one for each of the 40 images in the gallery set. Out of these values five highest values are taken up and their corresponding images from the gallery are displayed. These images are considered to be the closest match with the given query image. Out of these five gallery images, one image has successfully matched with the given query image and thus it is seen that the query image is correctly recognized. Fig.3 shows some instances where correct recognition is achieved. This paper focuses on performance comparisons with two baseline algorithms. The first one is a subspace method (PCA+LDA) implemented in the CSU Face Identification Evaluation System (csuFaceIdEval) V5.1 [27]. The other one is a local feature-based approach using LBP [28]. Two performance measures, the detection and identification rate (DIR) and the false alarm rate (FAR) are calculated for evaluation [29]. A Receiver Operating Characteristic (ROC) curve drawn by plotting DIR versus FAR is shown in Fig.3.

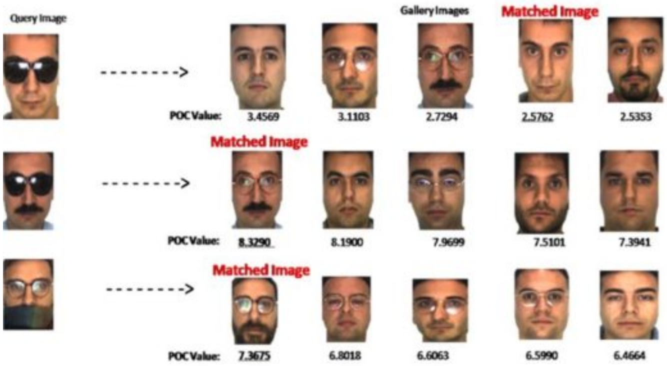


Figure. 3. Output results of the proposed method.

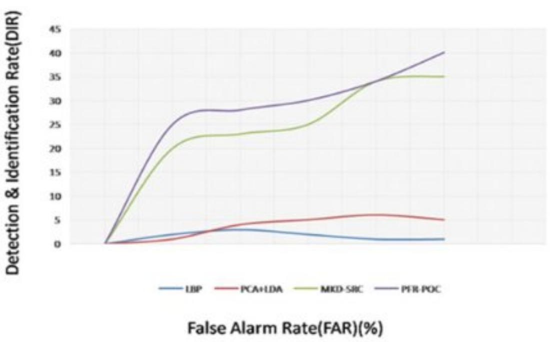


Figure. 4. ROC of the proposed method and other 3 methods on AR face database.

## V. CONCLUSION

In this paper the problem of recognizing a face from its partial image is addressed with an approach using POC. The proposed approach shows promising results on the partial faces with occlusion. Given an occluded image Q from the query set, this approach is able to provide five most matched mages G1-G5 from the gallery set out of which there exists one image that correctly recognizes the given query image. As future work, we propose to use larger database for both the query and the gallery set.

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