Novel Bound Setting Algorithm for Occluded Region Reconstruction for Reducing the Inpainting Complexity under Extreme Conditions

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ABSTRACT
Image Inpainting technique has been widely used for reconstructing damaged old photographs and removing unwanted objects from images. In this paper, we present a novel significant preprocessing step for periphery frontier setting technique which alleviates the process of image inpainting to a great extent. Our method improves the robustness and effectiveness by rational confidence computing method, matching strategy and filling scheme. Therefore, our method effectively prevents "growing garbage", which is a common problem in other methods. With our method, we can obtain preferable results to those obtained by other similar methods.

General Terms
Inpainting, Image Reconstruction, Bound Setting

Keywords
Image Color Analysis, Image Decomposition, Object Detection, Image Segmentation, Object Segmentation.

1. INTRODUCTION
In Face Detection , Face is detected based on the biometrics like the structure and shape of the face, presence of eyes, nose, mouth, eye brows, ears etc., Countless techniques on efficient face detection have been proposed with utmost precision and efficiency. But, the crisis arises in the segmentation phase wherein the need arises to extract the accurate face region in its entirety for the purpose of face analysis. Face Analysis is done to extract the psychological and psychic perspective.

Personality analysis based on individual facial features is for the most part subjective. We learn in Astrology that one must look at the total chart to understand the person's behavior and destiny. The same holds true for facial analysis. Different people with the same nose, eyes, or mouth, may have totally different personality characteristics, just as twins born at the same time, can be different in personality, learning abilities, and life goals.

We all read faces and size up people within minutes after we meet them. Early in life we learn to recognize facial features and expressions as a key to personality types. This is often based on stereotypic patterns and past experience with different types of people. Reality is about patterns that repeat in personal experience, so we can identify behavior.

Taking this to the psychic level, we not only view the face based on past conditioning and patterns of behavior, but we begin to intuit what a specific type of face means. This is sometimes based on ethnic and racial origins. Some people find a specific facial feature challenging, while others connect immediately. This goes to patterns of conditioning. Many people become skilled at analyzing personality types and disorders based on facial features, hair, facial expressions, eye movements, and particularly nervous facial habits is Image inpainting [1,2] provides a means to restore damaged region of an image, such that the image looks complete and natural after the inpainting process. Inpainting refers to the restoration of cracks and other defects in works of art. A wide variety of materials and techniques are used for inpainting. Digital inpainting are used to restore old photographs to their original condition. Recently we are using digital imaging with different techniques and approaches. The purpose of image inpainting is to remove damaged portions of an aged photo, by completing the area with surrounding or global information. The techniques used include the analysis and usage of pixel properties in spatial and frequency domains. Furthermore, image Inpainting techniques are used in object removal (or image completion) in photos. We ask that authors follow some simple guidelines. In essence, we ask you to make your paper look exactly like this document. The easiest way to do this is simply to download the template, and replace the content with your own material.

A review of the approaches to face detection proposed have been described in [2], [3] Sung and Poggio presented an example based learning approach for locating unoccluded human frontal faces. The approach measures a distance between the local image and a few view based "face" and "non face" pattern prototypes at each image location to locate the face. In [4], Turk and Pentland used the distance to a "face space", defined by "Eigen faces", to locate and track the frontal human faces. In [5], human faces were detected by searching for significant facial features at each location in the image. In [21] a deformable template based approach was used to detect faces and to extract facial features.

The convex hull, is one of the most fundamental structure in computational geometry and plays a central role in pure mathematics. The in depth study of the hulls is useful in its own right and as a tool for constructing other structures in a variety of circumstances in the design of algorithms. The computation of the convex hull of a finite set of points has found applications in diverse areas, such as pattern recognition, image processing, robotics, and stock cutting and allocation. Some of the most important applications are: Collision avoidance, Fitting ranges with a line, Smallest box and Shape analysis.

2. CURRENT WORK

Through this paper, a humble effort has been made to put forth an algorithm for bound specification for the skin regions to be inpainted in a static digital image.

In Skin detection or in particular face detection there are myriad techniques which have been put forth for the accomplishment of the task of efficient skin region detection with a exceptional detection rate in most of the cases. But, the problem arises when a certain definite skin region is to be segmented out for further analysis

Human Face analysis has been recognized as a crucial part in Intelligent Systems. However, there are several challenges to designing a robust and reliable face analysis system before their deployment in real world environments. One of the main difficulties is associated with the detection of faces with variations in illumination conditions and viewing perspectives. Through this work we put forth the development of a computational framework for robust detection tracking and pose estimation of faces captured by video arrays.

In recent years face detection and face analysis has been recognized as a crucial part in Intelligent systems and is an acclaimed research area. There are numerous commercial applications of face detection in face recognition, verification, classification, identification, as well as security access and multimedia. To extract the human face in an uncontrolled environment most of these applications must deal with the difficulties posed i n the form of variations in lighting, variations in pose, occlusion by various sources, in either cluttered or non uniform environments. The goal of the proposed work is to efficiently segment human faces, independent of their size and orientation from a known but uncontrolled background.

2.1.FaceRegion-Localization

Face detection can be regarded as a specific case of object-class detection. In object-class detection, the task is to find the locations and sizes of all objects in an image that belong to a given class. Examples include upper torsos, pedestrians, and cars. .Face detection can be regarded as a more general case of face localization. In face localization, the task is to find the locations and sizes of a known number of faces (usually one). In face detection, one does not have this additional information.

In this paper, face detection is done by using Skin Illumination Compensation Algorithm [1], which gives the localized face regions. All the Face Detection Algorithms have been proposed for the efficient accomplishment of detection of the position of the face. But, if the face region has to be localized for further analysis, the face detection algorithms fail to project the perfect complete face region. In the projected Face regions there will be some misdetected regions or some actual regions getting eliminated because of the Illumination variations across the face or due to changes in the environmental conditions or due to occlusions obstructing the detected face regions or low intensity input image or caemophlage . Because of these above mentioned variations or obstructions misdetections occur in the localized face regions. If the missing regions are well within the localized face, any of the inpainting algorithms could be adopted with formidable retrieval efficiency. But, If the missing regions is present along the boundaries of the detected face region, then the problem arises as to, what is the face region extent until which the inpainting operation has to be performed? i.e., deciding the bounds until which the inpainting is to be carried out. Is it until the image boundary is reached??? No!!! Edge Detection techniques also fail to provide the desired result with optimum efficiency and perfection. In this paper, we have taken an initiative to venture in this as unexplored area, to set the boundary of the detected and localized face regions.

2.2.ConvexHull

The application offered by Convex Hull has been exploited in here. The convex hull is then typically represented by a sequence of the vertices of the line segments forming the boundary of the polygon, ordered along that boundary. To show that the convex hull of a set X in a real vector space V exists, and any intersection of convex sets containing X is also a convex set containing X. It is then clear that the convex hull is the intersection of all convex sets containing X.

2.2.1.Algebraic-characterization

Algebraically, the convex hull of X can be characterized as the set of all the convex combinations of finite subsets of points from X: that is, the set of points of the form , where n is an arbitrary natural number, the numbers tj are non-negative and sum to 1, and the points xj are in X.

The convex hull is defined for any kind of objects made up of points in a vector s pace, which may have any number of dimensions. The convex hull of finite sets of points and other geometrical objects in a two-dimensional plane or three-dimensional space are special cases of practical importance. In computational geometry, a number of algorithms are known for computing the convex hull for a finite set of points and for other geometric objects, with various computational complexities.

Computing the convex hull refers to constructing an unambiguous, efficient representation of the required convex shape. The complexity of the corresponding algorithms is usually estimated in terms of n, the number of input points, and h, the number of points on the convex hull.

2.2.2.Aki-Toussaint-heuristic

This heuristic is used as the first step in implementations of convex hull algorithms to improve their performance. The idea is to quickly exclude many points that would not be part of the convex hull. This method is based on the following idea. Find the two points with the lowest and highest x-coordinates, and the two points with the lowest and highest y-coordinates. (Each of these operations takes O(n).) These four points form a convex quadrilateral, and all points that lie in this quadrilateral (except for the four initially chosen vertices) are not part of the convex hull. Finding all of these points that lie in this quadrilateral is also O(n), and thus, the entire operation is O(n). Optionally, the points with smallest and largest sums of x- and y-coordinates as well as those with smallest and largest differences of x- and y-coordinates can also be added to the quadrilateral, thus forming an irregular convex octagon, whose insides can be safely discarded. If the points are random variables, then for a wide class of probability density functions, this throw-away pre-processing step will make a convex hull algorithm run in linear expected time, even if the worst-case complexity of the convex hull algorithm is quadratic in n.

Known convex hull algorithms ordered by the date of first publication were initially analyzed with respect to their time complexity. Time complexity of each algorithm is stated in terms of the number of inputs points n and the number of points on the hull h. In the worst case h may be as large as n.

- Gift wrapping aka Jarvis march — O(nh)
- Graham scan — O(n log n)
- QuickHull — O(n log n)
- Divide and conquer — O(n log n)
- Monotone chain — O(n log n)
- Incremental convex hull algorithm — O(n log n)
- Marriage-before-conquest — O(n log h)
- Chan's algorithm — O(n log h)

The simpler optimal and latest output-sensitive algorithm discovered by Chan is used in our algorithm for its ideal time complexity. An output-sensitive algorithm is an algorithm whose running time depends not only on the size of the input but also on the size of the output. For the current problem domain where the output size varies widely, for example from linear in the size of the input to quadratic in the size of the input, analyses that take the output size explicitly into account can produce better runtime bounds that differentiate algorithms that would otherwise have identical asymptotic complexity.

2.3 Inpainting

Image Inpainting provides a means to restore damaged region of an image, such that the image looks complete and natural after the inpainting process.

The information loss could be caused by many reasons, for instance, transmission loss, or corruption of art works/photographs, intended or accidental damage, or due to partial invisibility caused by occlusion; image inpainting could also be used to create special effects, for instance specific object removal.

Applications of image inpainting range from restoration of photographs, films and paintings, to removal of occlusions, such as large unwanted regions, superimposed text, subtitles, stamps and publicity from images, reconstruction of scans of deteriorated images by removing scratches or stains, the removal of text and logos from digital images for the creation of artistic effects. Since most images are not composed of pure texture or pure structure, methods [6], [7], [8], [9] combine the advantages of both texture synthesis and mathematically computational image inpainting. Approach [6] decomposes the original image into structure and texture regions, and they are processed separately. The output image is the sum of the two processed components.

For structure and texture images, there are two classes of algorithms to tackle the inpainting problems: PDE/CoV (Calculus of Variation) based inpainting algorithms [10-13] for structure images and texture synthesis based algorithms [7][14][15] for texture images. The former class of algorithms completes the structure images by diffusing known surrounding information into the inpainting area, while the latter find texture block from known best matched block region formed by the neighborhood of a selected pixel on the boundary of the domain of inpainting, and then substitute the counterpart in the matched block for the unknown part of the pixel-neighborhood block. Image information could be categorized into three parts: shape (or structure), texture and color information [16]. While color images (or multi-spectral images) can be considered as several gray level images, structure and texture information separation are realized by Meyer [17]. There are a few works of hybrid inpainting algorithms based on image decomposition [6][18-19].

Irrespective of the categories of the image information possessed by the image to be reconstructed, the prime task of Inpainting is to fill in the missing part in an image efficiently and within the required extent of the respective regions of interest. But the Inpainting techniques fall short in deciding on the boundary of the region to be inpainted.

It is at this stage that our bound setting algorithm comes handy and is exceptionally helpful in optimizing the time complexity of the inpainting algorithm under extreme conditions depicted in the results and Table 1.

2.4 Algorithm

Step 1: Image captured and the actual skin regions are detected and localized.

Step 2: Face Regions are Detected and Localized using the Skin Illumination Compensation Algorithm [1].

Step 3: Localized Face Regions are removed and the Aki-Toussaint heuristic is applied as a preprocessing step.

Step 4: Finding the Convex Hull for the detected Face Regions is applied to determine the bounds for the detected Face Regions.

Step 5: Localized and Detected Face Regions are overlapped with their corresponding bounds evolved.

Step 6: Inpainting Techniques are applied for the regions for Efficient Reconstruction.

3. EXPERIMENTATION DESCRIPTION

3.1 Dataset

The experimentation has been carried out on an extensive dataset over different skin colors, different sized faces, different textured background, and vari ant illumination conditions across the face regions, with different percentages of occlusions, with different types of constructs present as occlusions etc., The size of the database is huge consisting of around 600 and odd photographs. Different image formats viz., jpeg, tiff, bmp, png, gif and the likes have been considered in the database for experimentation. Results obtained from the bound setting algorithm are very promising in terms of differentiating between different face regions under extreme conditions viz.,.

- If the face regions are in very close proximity with each other.

- In the presence of drastic variations in the skin colors of the different face regions.
- When there are intensity variations across the detected face regions. In the presence of different types and different sizes of structural elements in front of the face.
- In the presence of occlusions covering the face. When the face regions are overlapping each other i n the 2d plane.

3.2 Results/ Tabulation

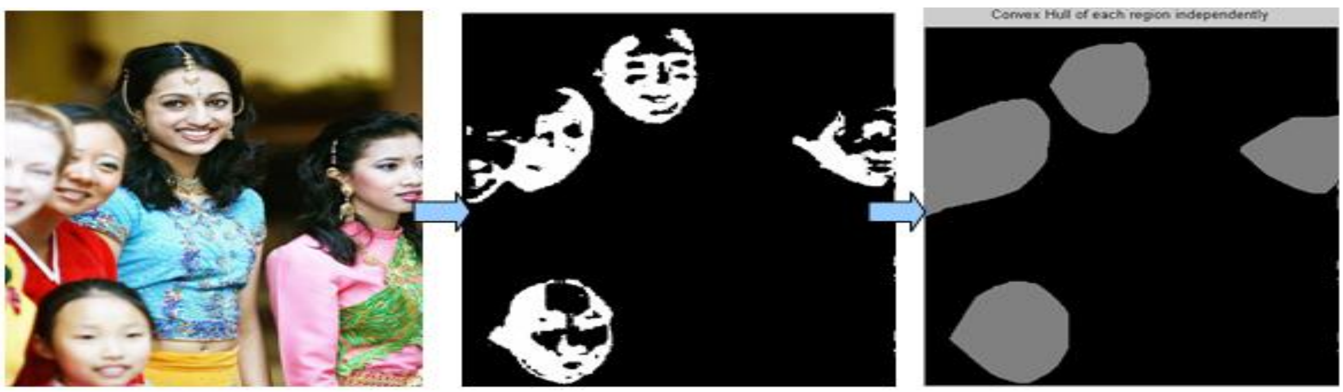
1: Original Image

2: Face Detected And Localized With Distortions In The Periphery of the detected face regions

3: Bounds set for Inpainting by the Proposed Algorithm

1 2 3

Fig 1: Deformities present due to the presence of high intensity values have been efficiently overcome in the output.

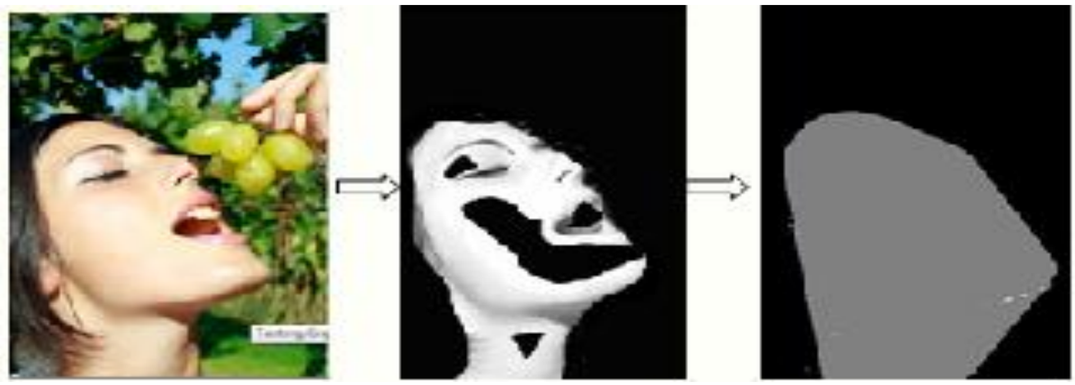


1 2 3

Fig 2: Deformities present in the detected faces due to occlusions and intensity variations set right in the output.

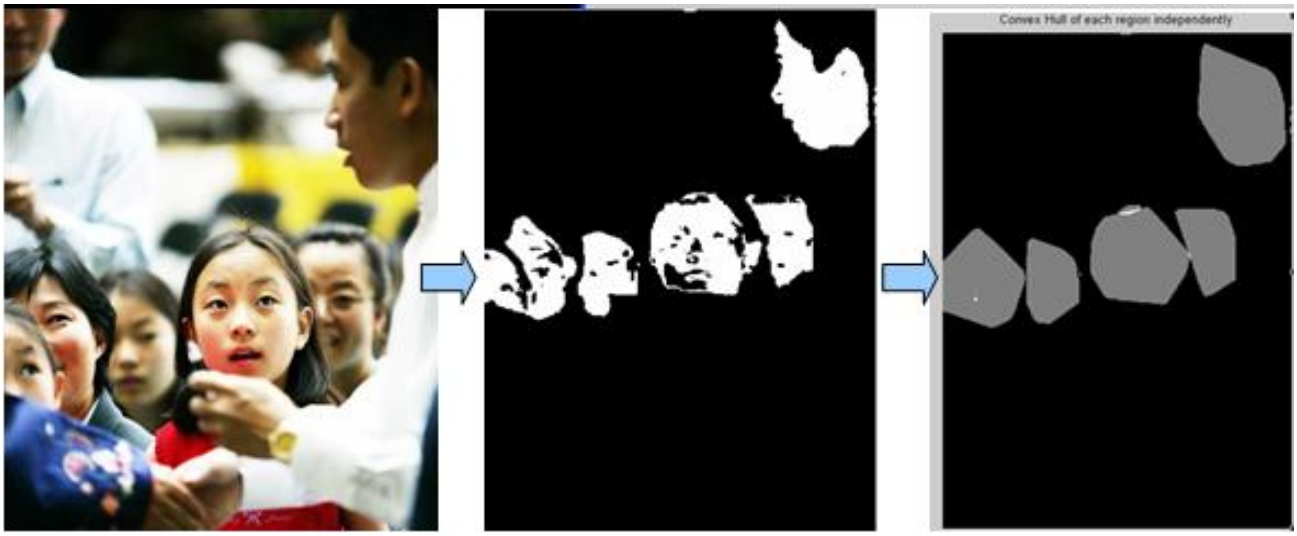
1 2 3

Fig 3: Overlapping and adjunct face regions clearly discriminated distinctly in the output.



1 2 3

Fig 4: Distortions due to drastic intensity variations across the face efficiently bounded and restored in the output.



1 2 3

Fig 5: Multiple Faces detected and distortions due to occlusions efficiently considered in the output.

Table: Conditions Considered for Experimentation.

Sl.No	%ge of Occlusion	Image Type	Skin Color	No. of Faces	Success Rate
1	0 – 25	jpeg/bmp/tiff/gif/png	All possible skin colors	1 – countably finite	98% - 100%
2	25 -50	jpeg/bmp/tiff/gif/png	All possible skin colors	1 – countably finite	95% - 100%
3	50-75	jpeg/bmp/tiff/gif/png	All possible skin colors	1 – countably finite	Around 85%
4	Above 75	jpeg/bmp/tiff/gif/png	All possible skin colors	1 – countably finite	Around 75%

4. CONCLUSION

Our Research Work is a humble step towards exploring this as yet unexplored area. Supportive and positive results from the Bound Setting algorithm has further motivated and triggered our inquisitiveness to go deeper into this exhilarating field of Image Bound setting and Reconstruction. Future Work would be mainly oriented towards face regions or any Image Region of Interest in general when the Occlusion of the corresponding regions are more than 50%.

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