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Remove Reflection Using Wavelet transformation Estimation

Yossra H. Ali [1], Maisa S. Mohsen[2]*
Department of Computer Sciences, Technology University, Baghdad, Iraq.

Abstract

Improving the performance of visual computing systems is achieved by removing unwanted reflections from a picture captured in front of a glass. Reflection and transmission layers are superimposed in a linear form at the reflected photographs. Decomposing an image into these layers is often a difficult task. Plentiful classical separation methods are available in the literature which either works on a single image or requires multiple images. The major step in reflection removal is the detection of reflection and background edges. Separation of the background and reflection layers is depended on edge categorization results. In this paper a wavelet transform is used as a prior estimation of background edges to separate reflection. Experimental results verify the effectiveness of the proposal in the speed and accuracy.

Keywords: Remove reflection, Mixture image, Reflection layer, Background layer, Separation.

ازالة الانعكاس باستخدام تحويل المويجات في التخمين

يسرى حسين علي [1]، ميساء سعدون محسن [2]*
قسم علوم الحاسوب، الجامعة التكنولوجية، بغداد، العراق

الخلاصة

ان تحسين اداء خوارزميات معالجة الصور يتم بازالة الانعكاسات الغير مرغوبة في الصور الملتقطة من خلال وسط زجاجي شفاف.

تتكون الصورة المنعكسة من تراكب طبقتين هما طبقة الانعكاس وطبقة الصورة الاصلية خلف الزجاج بشكل خطي. والحصول على هاتين الطبقتين بشكل منفصل يعتبر مسألة صعبة للغاية، لذلك ظهرت العديد من الخوارزميات التي تعالج هذه المشكلة والتي تنفذ اما على صورة واحدة او اكثر. والخطوة الاساسية في عملية ازالة الانعكاس تعتمد على تحديد حواف الصورة الاصلية والصورة المنعكسة لذلك عملية الفصل تعتمد على تصنيف الحواف .

في هذا البحث تم اقتراح استخدام تحويل المويجات لتحديد حواف الصورة الاصلية كتخمين اولي لازالة الانعكاس والنتائج التجريبية اثبتت صحة وفعالية الخوارزمية المقترحة من ناحية الدقة والسرعة.

1. Introduction

Everywhere in our daily life there are images with reflections. The image taken through a transparent glass is a mixture of two sources, the object transmission image and the reflection image of the scene reflected by glass [1], these mixture images can upset human perception and various computer vision algorithms as object detection and segmentation. Therefore, the separation and restoring the component layers is needed [2].

*Email: maisasadoon@yahoo.com

From a computational perspective, traditional imaging models suppose that the captured image I is a linear combination of a background layer BL and a reflection layer RL, $I = BL + RL$ (1). The separation of BL and RL from an input image I is the objective of reflection removal [3, 4], because the number of equations is generally half the number of unknowns, this problem is highly difficult [5].

To deal with reflection removal problem different methods have been introduced. Some of them utilized more than one input image to make the problem easier to fix by using series of images caused from a camera movement [6] or two images are captured with variant angles [7]. Another type of methods used a single superimposed image to separate reflections as [8] that is based on natural image priors such as sparsity prior, or the reflection edges less smooth than background edges suggested by [9], and the depth of field utilized in [10] to separate reflection.

All methods have their specific constraints relying on the nature of their priors. In real world scenarios, a single image based approaches is considered a limited efficiency because of the highly difficult nature of the problem, further the approaches suggested yet are often computationally ineffective [11].

This paper proposes an initial estimation of background layer to remove reflection from single mixture image using wavelet transforms.

The general structure for reflection removal process is described in Figure-1.

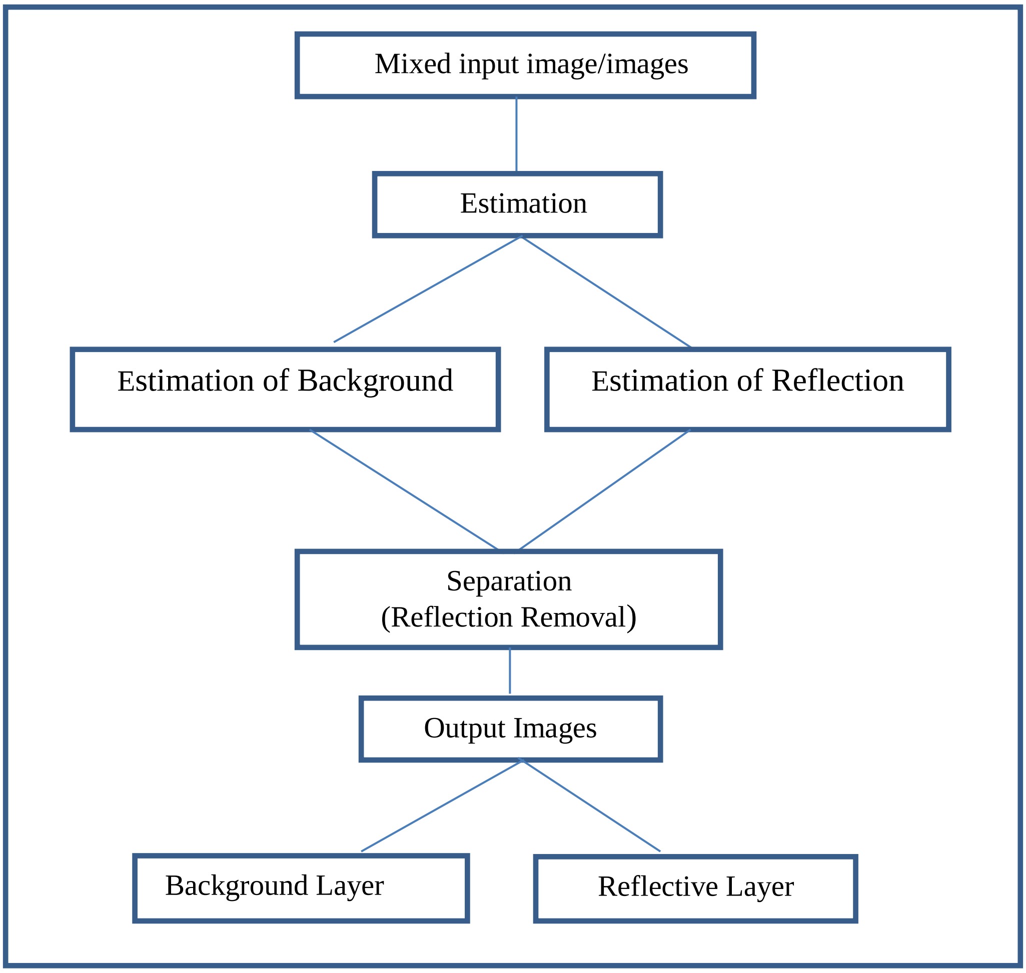


Figure 1- Reflection Removal structure.

The remnant of this paper is arranged as follows: in section 2, wavelet transforms and its benefit in edge detection is explained, in section 3, the proposal is described, section 4 is devoted to the experimental results that obtained after applying the proposal on methods that suggested in [10, 12] and Section 5 concludes the paper.

2. Wavelet Transform

Wavelets are mathematical functions that break data into various frequency components in addition to examine each component with a resolution matched to its scale. Analyzing physical situations is the advantage of the wavelets over Fourier methods, where the signal contains halts and sharp nails. The analyzing according to scale is the essential idea behind wavelets [13].

The multiresolution, compression, clustering and locality are the properties of the wavelet transform. These properties are appropriate for most applications in image processing involving edge detection [14]. Multiresolution analysis is the heart of wavelet analysis that analyze a signal information at separate scales [15].

The local consistency of functions can be described by a wavelet transform, leading to be an efficient method for image edge detection [16].

The high pass and low pass output of the wavelet transforms can be used to detect and analyze the edges of the image. The discrete wavelets band pass filters are used to decompose a signal into higher and lower frequencies; these filters work on by passing low frequencies as well as high frequencies into the low pass and high pass filter. An approximate coefficient represents the low frequencies and detail coefficients the higher frequencies in each level of wavelet decomposition [17].

The image is separated into four equal parts at the first level decomposition of two dimension discrete wavelet transform termed as approximation coefficients, horizontal, vertical and detail coefficients. The next level of decomposition uses the approximation coefficients that obtained in the first level [18].

The fluctuations of image grayscale levels can be analyzed locally by the wavelets without processing to produce a new image that can be used to separate the edges possibly [15].

3. Proposed Prior Estimation

The edge classification of the superimposed image into either reflection or object related is very important to accurate the separation that is depended on the estimation step of background and reflection in the reflection removal process.

The separation of reflection from only one mixture image is more difficult, methods to solve this problem have to require restrictions depended on the hypothesis from the prior knowledge and physical world.

This paper proposes background edge estimation as a preprocessing step to remove reflection using wavelet transform. The proposal algorithm is applied on reflection removal methods [10,12] that shows accurate results and high speed implementation.

The real life scenarios indicate that background edges are high intensity than reflection edges, but sometimes reflection edges have higher intensities due to light sources. Therefore pixel classification into background layer or reflection layer will be difficult. The proposal aims to obtain the more clear background layer.

The input to the proposal is a single image (I) taken in front of glass; the prior estimation of background begins by computing wavelet transform to the input image (I) that generates four coefficients(LL, LH, HL, HH); each of them has a quarter size of (I) and contains different information of the input image.

LL (Low Low) approximation coefficients: contains the most information of the input (I)

LH (Low High) horizontal coefficients: represents horizontal edge details.

HL (High Low) vertical coefficients: represents vertical edge details.

HH (High High) detail coefficients: represents diagonal details.

Edge isolation can be made by applying edge detector to the all coefficients after converting them to gray scale. Then a new image is extracted (RecI) by reconstruct the modified coefficients (LLg, LHg, HLg, HHg).

To deal with original edge intensity of (I), (RecI) is converted to binary using a threshold by create a new image (imc1) and then get the corresponding pixel values from (I) to edges in (imc1) and storing them in a new image (imc2), the output of the proposal algorithm (imc2) is applied on methods that proposed on [10] and [12] to separate reflection and obtain the background and reflection layers. Algorithm 1 describes the proposal work.

Algorithm 1: Prior Estimation of background layer to remove reflection from single image.

Input: input image I

Output: Background Layer image (BL) and Reflective Layer image (RL) of input image I

```
1-   (LL, LH, HL, HH)  ← Compute wavelet transform for I
2-   (LLg, LHg, HLg, HHg)  ← Convert (LL, LH, HL, HH) to gray scale
3-   (LLg, LHg, HLg, HHg)  ← apply edge detection (LLg, LHg, HLg, HHg)
4-   RecI  ← reconstruct image after edge detection (LLg, LHg, HLg, HHg)
5-   (convert (RecI) to binary)
     For i=1 to row (RecI) do
         For j=1 to col (RecI) do
             If RecI(i,j)<=0 then
                 imc1(i,j)  ← 0
             else
                 imc1(i,j)  ← 1
             end if
         end for j
     end for i
6-   For i=1 to row (imc1) do
         For j=1 to col (imc1) do
             If  imc1(i,j)=1 then
                 imc2(i,j)  ← I(i,j)
             else
                 imc2(i,j)  ← 0
             end if
         end for j
     end for i
7-   (BL,RL)  ← (imc2,I) apply on reflection removal method [10,12]
```

4. Results

To determine the performance of the proposal, an algorithm is implemented with two reflection removal methods in [10, 12] that originally deal with a single image, a fair comparison is made by applying the algorithm to same images of them.

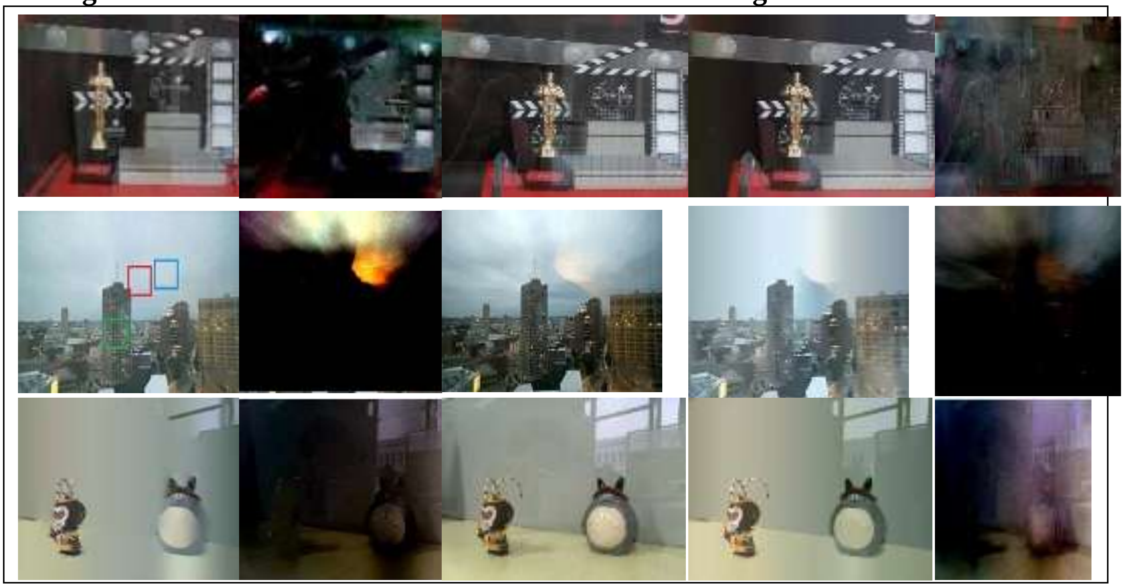
The comparison can only be seen with eyes since we do not have original images without reflections. Figure-2 (a) Figure-2 (b) illustrates results of the proposal compared with reflection removal method in [10] and in [12] respectively, that demonstrates a more accurate separation of reflection from background, a bright color for both background and reflection layers than methods in [10,12] that look like more darker, and clear details appeared in both layers. In addition to a high speed implementation which is expected due to dealing with edges rather than the whole image in some stages of the implementation. Table-1 shows the comparison of the computation time between the proposal and method in [10], while the computation time of the proposal and method in [12] is approximately equal. The experiments show that a wavelet transform help in the recovery of high quality results from just a single input image and high speed implementation.\

Table 1- Computation time comparison.

	Image size	**Computation time**
Proposal	200 × 300	2.0 minutes
Method in [10]	128 × 192	9.0 minutes

Method [10] **Input** **The Proposal**

Background **Reflection** **Background** **Reflection**



(a)

Method [12] **Input** **The Proposal**

Background **Reflection** **Background** **Reflection**

(b)

Figure 2- Results Comparison

5. Conclusion

The main objective of the reflection removal is separating the reflection with clear background from superimposed image utilizing one or more shots. This paper has presented a preprocessing proposal to estimate background layer initially from a single superimposed image. The proposal works by using wavelet transform for background edge detection. The proposal is tested on two recent methods [10, 12]; the proposal provides acceptable accuracy separation results and high speed implementation. The future work tends to extend or develop this proposal to build an algorithm can achieve a better performance than existing works.

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