Image Restoration on Motion-Blurred Images

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Abstract

Many pictures can be easily detected specific motion noise by camera. That kind of noise occurs because of several various source, such as motion of subject or camera. Restoration for these noise is important for image recognition. We will detect the blurred part in image and evaluate the detection performance with ground truth masks. Then, we will identify some parameters which are required for restoration such as motion direction. Finally, we will apply direct restoration technique to motion-blurred images introduced by Yitzhaky et al. [6]. Dataset which is 290 motion-blurred images is provided by The Chinese University of Hong Kong Image & Visual Computing Lab [8].

1. Introduction

The purpose of image restoration is recovering original image from degraded with prior knowledge of degradation process. The critical noises can be found normally, therefore restoration technique is import for recognition. There are many kinds of sources which makes noise, and rapid motion of object is one of the main source. To restore this kind of noise, several techniques were developed so far. Inverse filtering, wiener filter, MAP estimators and PSF(point-spread-function) restoring are examples.

We focus on the restoration of motion-blurred images. We will use some effective blur location detection and restoration techniques which are described in Section 2. For accurate and high performance restoration, various experiments and parameter tuning will be required.

Finally, we are going to create prototype that can be applied in real life. Our prototype is a program to restore the original image from the blurry image by using phone camera.

2. Methods

Our project consists of two main parts, which are detection of motion direction and restoration. The formal one is for detecting moving parts and declaring specific one dimensional direction of that parts. The latter one is for restoring motion noise. The formal one can be useful for latter one in some techniques.

Before the detection of motion direction and restoration, we need to extract the motion blurred part of image. We will use a various distinct characteristics of the blurred image, such as gradient distribution, power spectrum and local features.

To determine direction of motion, measuring the direction where the power spectrum of the image derivative is lower. For image power spectra, it is an excellent simple method the special isotropic first-order Markov chain can be useful [6].

For restoration, we declare unknown motion function in image using motion direction derived in the previous step, and apply several filters which can disassemble motion function.

2.1. Blur location detection

To detect the segmentation of blurred image, it is important to distinguish the difference between a blurred image and a clear image. Levin [1] found out that blurred and clear images show a big difference in gradient distribution, such as Kurtosis feature, and gradient histogram span. Also, A. Chakrabarti *et al.* [2] analyzed directional blur using power spectrum feature. Dai and Wu [3] developed a two-layer local learned filter to detect partial blur. Jianping Shi [4] combines these characteristics, then he developed a blur image detecting algorithm with great performance.

The algorithm proposed by Jianping consists of three stages. First, the algorithm pull out the four characteristics outlined above, such as Kurtosis feature, gradient histogram span, power spectrum feature and local learned filter. Second, it combines the four features using the naïve bayesian classifier. Finally, the blur image is derived from the graph cut algorithm using the most blurred image and the most clear image.

2.2. Motion-blurred image parameter

To solve the problem of restoration of images blurred by relative motion between the camera and the object scene, we should identify parameters with which to characterize the blurred image like motion direction, blur extent.

The first step of the method should be identification of the motion direction relative to the image axis. Yitzhaky *et al.* [5] found out that a derivative of the image in the motion direction should suppress more of the image intensity than a derivative in other directions. Therefore, motion direction is identified by measuring the direction where the power spectrum of the image derivative is lower.

The second step of the method should be identification of blur extent. When a derivative followed by an auto-correlation operation is carried out in the motion direction, a minimum can be expected in the autocorrelation function of the image derivative at a distance of the blur extent from the zero-shift center of the function [5].

2.3. Restoration of motion-blurred image

After calculating blur direction, then we should know blur function for restoration. The blur function can be completely described by the PSF(Point-Spread-Function) or the optical transfer function(OTF)[6]. OTF is the Fourier transform of the PSF. More specifically, OTF can be represented by MTF which is the absolute value of the OTF, and PTF(Phase Transfer Function) which is the angle of OTF [Eq. (1)].

$$OTF = MTFexp(j\ PTF) \tag{1}$$

We can measure ACF(Auto Correlation Function) of an M-pixel image line, and ACF of motion direction can be used for calculating PSF and OTF. Since the average ACF of the image derivative lines resembles the ACF of the PSF derivative, its discrete Fourier transform will resemble the power spectrum of the PSF derivative S_{dPSF} by using Eq. (2) [6]. MTF is absolute value of OTF [Eq. (3)] and PTF can be calculated with MTF by using Eq. (4). Using OTF, we can employ a simple Wiener filter to restore the blurred image [7].

$$S_{dPTF}(u) = |OTF(u)D(u)|^2 \tag{2}$$

$$MTF(u) = \sqrt{S_{\Delta f(u)}}/|D(u)| \tag{3}$$

$$PTF(u) = -\frac{1}{2\pi}\int_0^{2\pi} ln|MTF(\alpha)|\, cot\left(\frac{u-\alpha}{2}\right) d\alpha \tag{4}$$

3. Data

The Chinese University of Hong Kong Image & Visual Computing Lab provides the sample data for motion-blurred image and ground truth masks which is generated by 10 people [8]. Ground truth masks are black and white picture, white means the blurred part and black is not. We will use 290 motion-blurred images which has motion based noise and restore them for this project. Figure 1 shows some examples of motion-blurred image.

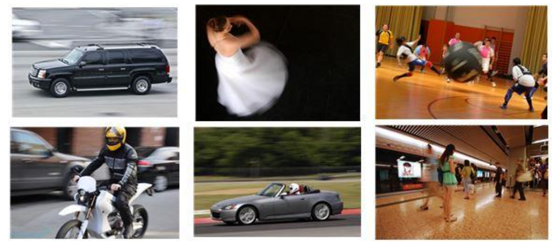

Figure 1: Example of motion-blurred image

4. Evaluation

To evaluate detection of blur part, we will compare ground truth masks and our results. We can compare this masks with our experimental results to evaluate the performance based on the intersection over union(IOU) ratio by using Eq. (5). Figure 2 shows some examples of ground truth mask which is matched with Figure 1.

$$\frac{R(A) \cap R(B)}{R(A) \cup R(B)} \tag{5}$$

Meanwhile to show that we have implemented the restoration correctly, we will compare motion-blurred image with restored image. And then we can convince reliability of the method.

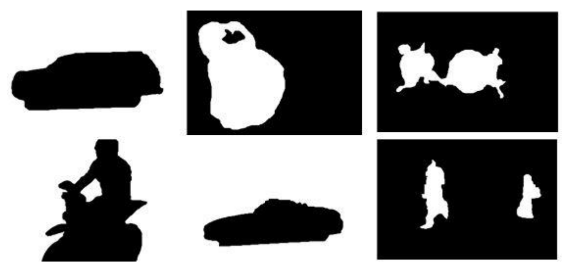

Figure 2: Example of ground truth mask

5. References

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