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MOTION DE-BLURRING FOR VEHICLE LICENSE PLATE IMAGES

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Abstract: Motion blur is caused due to relative motion between the original scene and the camera, during the integration time of the image. Motion blurring causes problems in license plate recognition, as the characters on the license plate cannot be recognised due to distortion caused by blurring. Hence, de-blurring of license plate image is required, so that character recognition is possible. **De-blurring** ***is the process of removing*** **blurring** ***artifacts from an image. The process of motion de-blurring can be divided into two parts: the estimation of the function that caused the blur (the degradation function), and application of a restoration algorithm to the de-blurred image. The proposed system first detects license plate in an image, then de-blurring is performed on the license plate image. A de-blurring kernel is used to perform convolution over the license plate image, which de-blurs it. The proposed de-blurring kernel is a novel kernel, which is derived using a combination of a Gaussian kernel and a sharpening kernel.***
Keywords: convolution; de-blurring; kernel; motion blurring;

I. INTRODUCTION

Blurring is the obscuration of something, or making something unclear or indistinct. In image processing, blurring means obscured or unclear image, due to noise or some other artifacts.

Types of blur:
i) Defocus aberration: Defocus [1] is the aberration in which an image is out of focus. Defocus refers to a translation along the optical axis away from the plane, or the surface of best focus. This aberration results in reduction of the sharpness and contrast of the image.
ii) Gaussian Blur: A Gaussian blur [2] is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics. Gaussian blurring is usually used to reduce detail and image noise. The equation of a Gaussian function in one dimension is

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$$

iii) Motion Blur:Motion blur [3] is the result of the relative motion between the camera and the original scene during the integration time of the image. It is clearly seen in the pictures that were taken with long exposure times, and in pictures of fast moving objects. The motion blur effect is often used in computer graphics to make synthetic images and animations look more realistic and to add additional information about the direction of the motion. There are two causes of motion blurring - movement of the object, or movement of the camera (i.e. camera shake), or both.

Motion De-Blurring:
The process of motion de-blurring can be divided into two parts: the estimation of the function that caused the blur (the degradation function), and applying a restoration algorithm. Since the motion path can be arbitrary, the first problem can be hard to solve.

Kernel:
A kernel [5] (also known as mask or convolution matrix) is a small matrix which can be used for, embossing, blurring, sharpening, edge detection, and for applying many more effects. This is achieved by convolution between a kernel and an image.

Convolution:
Convolution [4] is a mathematical concept and also an important tool in data processing, particularly in digital signaling and image processing.

II. RELATED WORK

A. Robust Blur Kernel Estimation

In [6], for license plate image blurring caused by fast motion, the blur kernel can be viewed as a linear uniform convolution and parametrically modelled with length and angle. The proposed scheme is based on sparse representation for identification of the blur kernel. Analysis of the sparse representation coefficients of the recovered image determines angle of the kernel based on the observation that the recovered image has the sparsest representation when the kernel angle corresponds to the genuine motion angle. Then, the motion kernel length is estimated with Radon transform in Fourier domain.

B. Neural Networks for Motion De-blurring

This is an approach to blind deconvolution which relies on convolutional neural networks (CNN) [7] that are trained on a large set of artificially blurred images to directly de-blur images. It demonstrates that neural networks trained on artificial data provide superior reconstruction quality on real images when compared with traditional blind deconvolution methods.

C. Edge-based Blur Kernel Estimation

In [8], a patch-based strategy is introduced for kernel estimation, for blind deconvolution. To choose proper patch priors, both statistical priors learned from a natural image dataset and a simple patch prior from synthetic structures are examined. It is observed that the patch prior prefers sharp image content to blurry ones. Based on the patch priors, the partial latent image and the blur kernel can be iteratively recovered. This approach achieves state-of-the-art results for uniformly blurred images.

D. Kernel fusion for image de-blurring

Kernel estimation for image de-blurring is a challenging task, and a large number of algorithms have been developed for kernel estimation. Individual kernels estimated using different methods alone are sometimes inadequate for complete de-blurring of the image. Hence in [9], the problem of fusing multiple kernels estimated using different methods into a more accurate one that can better support image de-blurring as compared to each individual kernel has been addressed. Our proposed system is inspired by a similar principle of kernel fusion in the context of image de-blurring, to directly obtain a kernel by merging/combining principles of two or more kernels.

III. METHODOLOGY

In the proposed system, a novel kernel has been derived using a combination or fusion of the principles of a Gaussian kernel, edge kernel and a sharpening kernel for the purpose of de-blurring the license plate image. Superimposition of the outputs obtained by applying these kernels yields a sharper image. Hence in the designed kernel, the combined effect of these kernels leads to the de-blurring effect. The direction of motion of the cars is such that horizontal lines are blurred considerably. This was known and kept in mind while deriving the kernel. The kernel used is a 5x5 matrix. Since the motion of the vehicles in the captured images is of relatively higher speed, it is required to use a kernel with higher dimensions (i.e. 5x5), as the motion causes the pixel values to spread over a larger bandwidth of the image area.

IV. SYSTEM REQUIREMENTS

A. Interface Requirements

i.) Hardware Interfaces
- Processor: Intel i3, i5, i7
- RAM: 4GB, 8GB
- System Type: 64-bit Operating System

ii). Software Interfaces
- Language: C++
- Operating System: Windows 7, 8.1 and 10
- Platform: OpenCV 3.1.0
- IDE: Microsoft Visual Studio (2015 Community Edition)

B. Assumptions and Dependencies

1. The camera used has a CMOS sensor.
2. The camera is stationary and placed at a distance of 20 to 30m from the vehicles.
3. The input images are taken from a toll-booth video.
4. The input image format is PNG or JPG.
5. The output is in the form of images.
6. The blurring is uniform.

C. Limitations

The detection of license plate fails under the following circumstances:
1. If the plate is obscured by the dirt and grime.
2. If the font used is not regular.
3. If the license plate is covered by stickers or stamps.
4. If the plate is extended vertically (text is divided into two parts).
5. If there is too much glare on the license plate.
6. If there are multiple license plates in the image.

V. SYSTEM DESIGN AND IMPLEMENTATION

The flow of the proposed system is as follows:

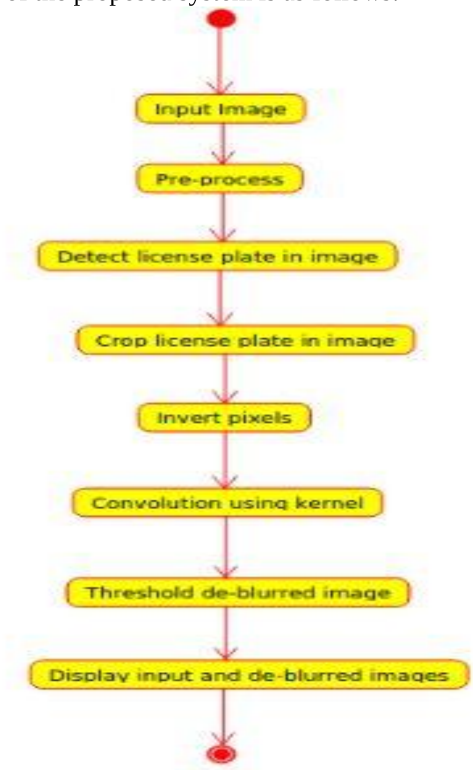

Fig.1. Flow of system

Input to the system is an image of a vehicle which is taken from a toll booth video. Pre-processing is first carried out on the image. This includes gray scaling, noise removal, thresholding and image enhancement. Then, license plate in the image is detected using connected component analysis technique. Detected license plate is then cropped and pixel inversion is performed. The de-blurring kernel is convolved over the license plate image, and final de-blurred license plate image is obtained.

VI. TEST RESULTS

Fig.2. Blurred input image

The test images are the frames of a video taken at a toll booth. Since the camera is fixed, direction of vehicle's motion is towards the camera. Hence the vertical edges remain more or less intact, but there is considerable blurring of horizontal edges (like the horizontal line in 'H'). The objective of de-blurring therefore is to recover the blurred horizontal edges. The various kernels used are:

A. Kernel 1:

$$\begin{bmatrix} -8 & -4 & 4 & -4 & -8 \\ -4 & 2 & 8 & 2 & -4 \\ -2 & 4 & 32 & 4 & -2 \\ -4 & 2 & 8 & 2 & -4 \\ -8 & -4 & 4 & -4 & -8 \end{bmatrix}$$

De-blurring result:

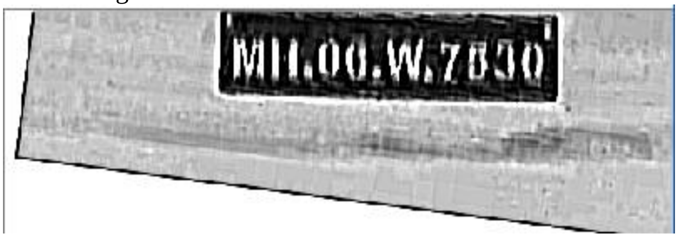

Fig.3.

B. Kernel 2:

$$\begin{bmatrix} -6 & -2 & 4 & -2 & -6 \\ -4 & 2 & 8 & 2 & -4 \\ -2 & 4 & 32 & 4 & -2 \\ -4 & 2 & 8 & 2 & -4 \\ -6 & -2 & 4 & -2 & -6 \end{bmatrix}$$

De-blurring result:

Fig.4.

C. Kernel 3:

$$\begin{bmatrix} -1 & -2 & -4 & -2 & -1 \\ -2 & -4 & 12 & -4 & -2 \\ -2 & 8 & 30 & 8 & -2 \\ -2 & -4 & 12 & -4 & -2 \\ -1 & -2 & -4 & -2 & -1 \end{bmatrix}$$

De-blurring result:

Fig.5.

D. Kernel 4:

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 2 & 2 & 4 & 2 & 2 \\ 1 & 1 & 1 & 1 & 1 \\ -2 & -2 & -4 & -2 & -2 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

De-blurring result:

Fig.6.

Kernels 1, 2 and 3 are used to de-blur in both horizontal and vertical directions. The results obtained are not satisfactory. Kernel 4 takes into account de-blurring only in horizontal direction. As seen in figure 6, the horizontal edge of the letter 'H' is recovered in the image of kernel 4. After segmentation of Figure 6, connected components will be obtained, including a connected 'H' i.e. the letter 'H' is successfully recovered after convolution with kernel 4. Kernel 4 is thus the final kernel that can be used for the de-blurring of the license plate images, and for obtaining connected license plate characters.

VII. CONCLUSION

The system highlights a novel kernel which achieves de-blurring of license plate images where the direction of motion is known, and leads to obtaining of better connected components i.e. connected characters on the license plate. The kernel is a generic kernel which does not take into account the image properties. Further research can take these properties into account, which can lead to better results. Also the proposed kernel assumes uniform blur across image. Better results can be obtained if different kernels are used for different areas of the image, according to degree of blurring.

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