Tilt correction of images used for surveillance

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Abstract— Tilt correction of images is an important step of different object recognition algorithms. In this paper we proposed a method to correct the tilt in images using linear symmetry feature. Linear symmetry feature is extensively used in OCR technology and finger print recognition. We propose to use this in a generalized way to recognize the tilt in surveillance images. Long and sharp vertically or horizontally oriented edges in the image are used as reference for tilt correction.

Keywords— Gaussian filter, linear symmetry, noise removal, orientation tensor, skew detection, skew estimation and removal, Tilt correction.

I. INTRODUCTION

In the images captured by surveillance cameras the tilt can occur due to misalignment of the camera as it is dynamic handled or due to the faulty alignment of objects where the objects deviated from their original inclination. The amount of tilt can be recognized using the proposed method. The orientation of the major objects in the image provides for the perception of tilt in the image. The orientation of the major objects can be calculated by computing the orientation tensor of the image which in turn can be predicted by calculating the linear symmetry feature present in the image [1]. Linear symmetry feature is defined as the lines present in the image along which the direction of pixel value change is consistent. It is computed by calculating the second order complex moment [2]. The orientation tensor thus estimated will give the perception of the amount of skew present in the image. The linear symmetry feature is extensively used in OCR technology [3] and finger print recognition algorithms [4]. In this paper we tried to extend this idea to surveillance images which are more generalized in nature. The occurrence of tilt in surveillance images are more compared to OCR and finger print images, as they are captured in dynamic environments. Hence tilt correction becomes an important part at the time of processing of these images. We propose to use orientation tensor to calculate the angle of tilt in this case based on linear symmetry feature.

As the surveillance images are usually captured in human occupied areas and jungles, the presence of houses, buildings, long trees etc. contribute long and sharp vertically or horizontally oriented edges to the image. These edges can be used as reference for tilt correction. Using our proposed method we have recognized the orientation angles of these long edges to calculate the amount of tilt in the image.

II. METHODOLOGIES

The proposed method works in several steps. As the images captured by surveillance cameras might be noisy due to its set up area, noise removal becomes an integral part of the method. After removal of noise, the orientation tensor has to be calculated in terms of second order complex moments as stated in [1]. This will give an estimation of the linearly symmetric zones in the images. The next step is the tricky part, where the dominant linear symmetric zones have to be estimated. In figure 2 the zones of the image of figure 1, where linear symmetry feature exists is shown in white shades. Clearly the white shaded areas are the zones where grey values change along a line from a particular direction. In other words, it is also giving the perception of the presence of different objects and their orientation in the image.
Figure 1. The original image

Figure 2. The linear symmetry feature identified image

Figure 3. The area providing towards the orientation of the image have been identified

Figure 4. Bottom half portion of Figure 2

However all the contents of the image do not give the perception of the overall orientation of the image. In figure 4 the bottom half of the figure 2 has been depicted. By looking at figure 4 it is difficult to say anything about the overall orientation of the image; although linear symmetry exists there. By comparing figure 4 and figure 2 it can be observed that the area enclosed by red ellipse in figure 2 is the dominant linear symmetric zone, which is giving the perception of the tilt in the image. The red ellipse enclosed zone is the area where the amount of linear symmetry is near maximum. The orientation of this area will give the amount of tilt in the image. If the orientation tensor of this area is extracted, then also the perception of tilt of the overall image is preserved which can be observed from figure 3.

The orientation angle of this dominant zone w.r.t the primary axes will indicate the amount of tilt in the image. The proposed method is described in the block diagram in figure 5.

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**Figure 5. Steps of the proposed method**
III. MATHAMETICAL FORMULATION

3.1. Noise Removal
To remove the noise, a 2-D Gaussian averaging filter can be used. However two dimensional Gaussian averaging filters are linearly separable [1]. Hence we used two Gaussian averaging filters by using (1) and (2).

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

\[
G(y) = \frac{G(x)}{G(x)} \quad (2)
\]

3.2. Orientation Tensor calculation of the entire Image
Orientation tensor in terms of linear symmetry feature [4] gives the average direction in a local neighborhood. Linear symmetry feature in spatial domain can be calculated using the second order complex moment [1] [5] using the eqns. (3) and (4)

\[
I_{20} = \sum \sum (f'_x + i f'_y)^2 \cdot z(x, y) \quad (3)
\]

\[
I_{11} = \sum \sum (f'_x + i f'_y)(f'_x - i f'_y) \cdot z(x, y) \quad (4)
\]

where \( f'_x = \frac{\delta f}{\delta x} \) and \( f'_y = \frac{\delta f}{\delta y} ; f \) is the image function.

\[
z(x, y) \text{ is a Gaussian averaging function.}
\]

Here \( f'_x \) and \( f'_y \) provide the gradient vector of a particular pixel position in \( x \) and \( y \) directions respectively w.r.t its neighboring pixels. For a particular pixel position, the second order complex moment \( I_{20} \) of equation (3) indicates the average direction at that location. To calculate \( I_{20} \) for a particular location, the complex directional vectors over small neighborhoods in terms of \( f'_x \) and \( f'_y \) are summed over a larger Gaussian averaging window as in eqn. (3).

The next second order complex moment \( I_{11} \) as in eqn. (4) is the summation of the absolute values of the all the gradient component vectors over the same Gaussian averaging window.

3.3. Orientation Tensor extraction of the dominant zone
By comparing \( I_{20} \) and \( I_{11} \) [2] using the eqn. (5) the presence of perfect linear symmetry can be predicted.

\[
l = \frac{I_{20}}{I_{11}} \quad \text{where} \quad I_{11} \neq 0 \quad (5)
\]

Here, clearly \( l \in \{0, 1\} \). \( l = 1 \), implies that all the component gradient vectors have same direction; i.e. the magnitude of the resultant vector and summation of magnitudes of individual vectors have the same value. It implies that the presence of total linear symmetry is there. On the other hand, \( l = 0 \) implies the total absence of linear symmetry. It can be said that if the value of \( l \) is closer to 1 for a particular location, near perfect linear symmetry exists there. Hence, those values of \( I_{20} \) have to be retained for whom \( l > C \) holds, where \( C \rightarrow 1 \_ \) according to eqn. (6).

\[
ID_{20}(p,q) = \begin{cases} 
I_{20}(p,q) & \text{if } I_{11}(p,q) > C \\
0 & \text{otherwise}
\end{cases} \quad (6)
\]

The 2-D matrix thus obtained by eqn. (6) will contain the information about those dominant linear symmetric features which will give information about the existence of tilt in the image. The average orientation tensor for the entire image can be calculated by the eqn. (7).

\[
l = \sum \sum ID_{20}(x, y) \quad (7)
\]
The dominant orientation of the image will give the amount of tilt in the image. It can be calculated by the calculating the argument of the complex average orientation tensor of the entire image.

\[ \theta = \angle \mathbf{I} \]  

(8)

If the image is rotated by the angle, \( \theta \) obtained from eqn. (8), the tilt will be corrected.

IV. EXPERIMENTAL RESULTS

We used MATLAB for simulating our proposed method. In figure 6. and figure 7, the noisy image and filtered image using Gaussian smoothing filters with \( \sigma = 1.2 \) are shown.

The next step was to calculate the orientation tensor to detect the linear symmetry. The linear symmetry calculated image is shown in figure 8 and figure 9.

![Figure 6. The original image](image1)
![Figure 7. The noise removed image](image2)

Figure 6. The original image

Figure 7. The noise removed image

![Figure 8. Linear Symmetry calculated image](image3)

Figure 8. Linear Symmetry calculated image

In figure 9 by observing the object enclosed in red ellipse it can be noticed that the object is tilted to its left which should be vertical. However due to camera orientation at the time of capturing the image, it is tilted. After tilt correction using our proposed method, the result is shown in figure 10.

![Figure 9. The contents of the image contributing towards the orientation of the image are shown in black and white](image4)

Figure 9. The contents of the image contributing towards the orientation of the image are shown in black and white
V. CONCLUSION

The proposed method can be used for estimation and correction of tilt in images in automated processes. Potential application areas can be two fold. In case of surveillance images, where images are tilted due to misalignment of cameras, the tilt can be corrected so that the object recognition algorithms can be applied efficiently. Sometimes the objects are tilted from their natural positions, e.g. due to construction fault buildings can be tilted and such kinds of defects can be predicted by this method.

REFERENCES