Brightness normalization for Blurred Image Matching

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Abstract. Blurred Image Matching (BIM) is based on image pre-processing and Blob detection. BIM methods has been designed to function with images presenting a strong level of noise of different kinds. The technique shows an excellent robustness, speed and unique features when compared to existing methods. This article investigates the process BIM is based on, proposes a new way to improve the range of noise the technique can process with a good range of success by adding image normalization. Moreover, the article investigates the technique's performances when confronted to different parameters, thus suggestion an ideal brightness for the blob detection to perform at the best of its capacities.

1. Introduction

Blurred Image Matching (BIM), is a key point detection method for images. It is based on the comparison of large areas of interest in images, after a preprocessing involving Gaussian blurring and thresholding. The technique selects large areas identified using a connected components labelling algorithm and matches them from an image to another.

As shown in previous researches, one of the main issues in stitching images using BIM is their brightness level. Thresholding algorithm are by essence heavily impacted by brightness levels. Therefore, it was very difficult to find key points in images presenting different expositions. Different expositions can results from different angles of view, time of the day, metrological phenomena.

In this context, it was necessary, for many samples to first normalize the images characteristics. This normalization would allow finding comparable shapes as used by BIM.

2. Dataset

The dataset used in this experiment are sets of aerial pictures taken by drone, those images include a wide range of colorimetry and brightness in their original state. 917 Images were used, divided in 4 categories. The brightness

2.1. Evaluate brightness

Brightness is one of pixel's most significant characteristics; however, there is no standard formula for its measurement. In this paper, we used color vector length and base ourselves on arithmetic model mean [1]:

$$Br = \frac{1}{n} \cdot \sum_{i=0}^{n} \frac{(r_i + g_i + b_i)}{3}$$

Where n is the amount of pixels in the image and r, g and b, the value for each pixels in red, green and blue.

2.2. Define brightness equalization necessity for a set

Experimentations shows that BIM present optimal performance when the difference of brightness between images stays under 5%, especially when using shape contouring for comparison instead of quadrilaterals [BIM1]. Therefore, the formula serving to assess the necessity of normalization presents itself as such

$$\left|\frac{Br_1 - Br_2}{Br_1 + Br_2}\right| < 0.05$$

2.3. Define ideal brightness

Represents the amount of points found depending on images brightness; it shows that the different sets of images with a significant range of characteristics, present comparable areas of matching. Although colorimetry plays a role into shape matching, it seems not to be a relevant feature regarding brightness [third article BIM]. It has been shown in previous experiments that specific colour channels has an influence of points matching after the thresholding operation [third article BIM].

The totality of the points were found in between a brightness of 38 and 161 (23% of the spectrum, hereafter referred as partial brightness spectrum). Which highlight the importance of the brightness for BIM processing. Moreover, the majority of the points, (-0.25σ to 0.25σ) are situated in a range between 89 and 113, or just under 7% of the full brightness spectrum and about 32% of the partial brightness spectrum.

The ideal interval is to be found where the average brightness of the final image lays in the interval defined in 0

Define ideal brightness and confirmed in 3.1 Average brightness modification.

Therefore, the ideal interval is in a brightness range between 78 and 110, where shapes are the more distinctive and where brightness of both images is equal. Which leaves two areas, on the center of both diagonals for which all images respects the following formula:

$$110 > Br > 78$$

3. Equalize

Brightness changes between pictures, whether they come from different exposition time or were taken at different time, with different environmental conditions. Concretely, our objective was to equalize histograms in order to find the same objects of interest from an image to another [2].

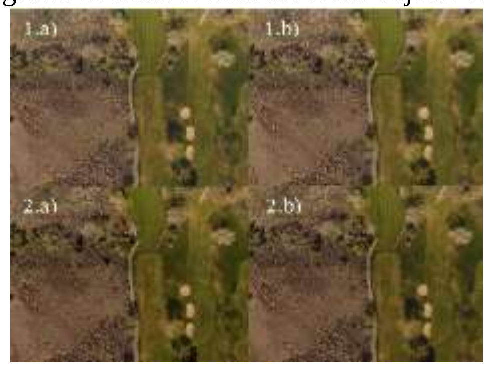

Figure 1. Pair of images having different, opposite brightness. They are "twin" points on the opposite diagonals of **Ошибка! Источник ссылки не найден.**.

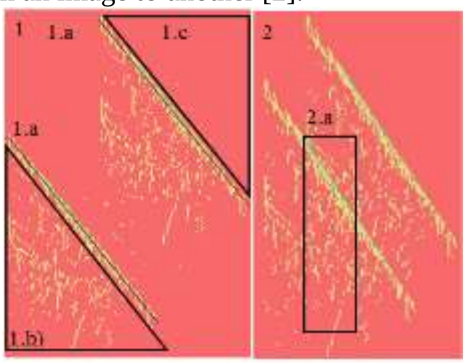

Figure 2. Difference matching results' histogram. On the left, the image's average brightness difference is 120% higher than on the right. The original image is the same.

3.1. Average brightness modification

As shown on **Ошибка! Источник ссылки не найден.**, where the X and Y axis are different values of images' average brightness, from -255 to 255. The results of successful matching are presented on a pair of diagonal **Ошибка! Источник ссылки не найден.**.1.a, the two original images having different brightness, there are two combination for each coordinate, for example (-21;33) and (-33;21) as shown on **Ошибка! Источник ссылки не найден.**.

A smaller brightness difference between pairs of images is showed on **Ошибка! Источник ссылки не найден.**.1 and **Ошибка! Источник ссылки не найден.**.2 (histogram 1 for the pair with the highest delta, histogram 2 for the pair with the lowest delta), the closer the two diagonals, the lower the delta, which results in a less significant brightness correction. The best results appearing when no brightness difference exists, then the two diagonals are merged into one.

On **Ошибка! Источник ссылки не найден.**, the area directly below (**Ошибка! Источник ссылки не найден.**.1.b) the diagonal shows dispersed points; those are either noise or isolated points that are very distinctive shapes on an image. Brightness change has a lesser impact on such shapes; they are usually caused by a sudden change of colour in the landmark (such as a red roof in a green forest). The area directly above the diagonal (**Ошибка! Источник ссылки не найден.**.1.c) is empty as it represents the part of the array where images are brightness correction of both images diverge in opposite directions; any point is this area is extremely likely to be noise.

Ошибка! Источник ссылки не найден..2.a also confirms the results obtained in 0

Define ideal brightness, it is then mentioned that 60% of the points could be found in 32% of the partial brightness spectrum. The shape 2.a contains 33% of the given spectrum and contains 62.8% of the points matched. This information also establishes a direct link between the amount of points and their quality and the amount of points found can be used as feature without the need of running matches.

4. Conclusion

BIM performs best with a brightness range between 78 and 110, with the highest peak at 91. 91, is therefore the recommended image brightness value when operating BIM.

The experiment presented in this paper allowed to successfully determining sets of preprocessing parameters, while proposing a process modification allowing BIM to perform with a higher robustness than previously, introducing the treatment of new noise sources in BIM’s abilities range.

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