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Accuracy improvement of edge image recognition AI in dark light environment by image enhancement

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Abstract. In order to solve the problem of poor image recognition accuracy of edge devices in the dark environment, the author simulate the change of brightness and contrast in the dark environment by using matlab's internal function on the image through the point operation method in matlab, and add Salt & pepper and Gaussian noise to simulate the noise generated by the image in the dark environment. The modified images are imported into the image recognition system trained by migration learning to compare the changes in recognition accuracy and to investigate the main factors affecting the image recognition accuracy in low light conditions. Meanwhile, the main factors affecting the image recognition accuracy are improved by median filtering and Wiener filtering to find the image enhancement method that is most beneficial to improve the image recognition accuracy of edge devices in the dark light environment. The experimental results show that the main factor affecting the image recognition accuracy in the dark environment is the Salt & pepper noise, and the median filtering can remove the Salt & pepper noise well and improve the recognition accuracy of a single image up to 70%.

Keywords: Image, Recognition, Enhancement, Low Illumination, Transfer Learning.

1. Introduction

At present, graphic recognition technology has penetrated into all aspects of people's lives, use of image recognition technology in various situations. Along with the development of mobile devices and mobile networks, edge devices such as cell phones, tablets, watches, etc. have also started to have image recognition functions. Since the scenes of image recognition are very diverse, the lighting conditions that different scenes can provide are also different, thus making the image quality provided for image recognition uneven. Now the development of image recognition technology has been more mature, but in the face of some imaging environment bad situation such as fog, rain, dark light environment when the image recognition accuracy still needs to be improved. One of the most common adverse environments is the dark light environment. Low-light images[1] have low signal-to-noise ratio and low luminance contrast compared with ordinary visible images, which are not favorable for target detection and recognition[2]. Nowadays, most of the image recognition for dark light environment uses the method of adding external light source, such as flashing light at the entrance of underground garage. However, the method of adding light source not only increases the cost of equipment, but also provides no additional light source for image recognition at all for edge devices. The current image enhancement technology Retinex theory is representative for low

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illumination images, and also compressed domain image enhancement is representative[3]. In this paper, the author hope to achieve the image enhancement technology to improve the image recognition accuracy of edge devices in dark light environment by software without the help of external light source. The image recognition platform used in the experiments is trained by edge impulse using a migration learning approach is capable of recognizing cats and dogs. Image enhancement is implemented based on matlab programming.

2. Image platform and training methods

Edge Impulse is a development environment for edge computing devices to implement machine learning[4]. Edge impulse provides developers with machine learning support through an open source device software suite that enables processes from data phones, data processing, neural network training, and final deployment.

The training set and test set used in the training of the image recognition system used in this paper were collected from cat and dog photos after screening on the Internet. 4000 pictures of cats and dogs were used in the training set, totaling 8000 pictures. Since the number of training sets was small compared to the final image recognition system deployed in the market, and the classification of cats and dogs is a very classical image recognition problem, the migration learning method was used to help obtain better recognition performance[5]. After the training, the accuracy of the model is 86% for cat pictures and 85.5% for dog pictures, with an overall accuracy of 85.75%.

3. Imaging quality problems with low-light pictures and its effect on image recognition

The current quality problems of images in low light conditions are mainly the following three points. First of all, the low light environment causes the overall contrast of the image to be lower compared to the normal light, and the normal light can help the image achieve good color contrast while the dark light conditions will show the overall gray texture of the picture. At the same time, due to the lack of light in the dark environment, the details of the physical objects can not be accurately presented on the photographed pictures, and may even blend with some of the surrounding environment to form a false sense of view. Third, due to the dark environment caused by the lack of light intake, in order to improve the brightness of the picture as much as possible, you need to adjust the camera ISO to increase the amount of light intake, which in turn leads to the image noise will be much more serious than normal lighting conditions. The above three imaging quality problems on the overall image clarity, detail performance, gray level, black and white contrast and other convenient have a great weakening[6].

The process of image recognition is to extract features from a given image to be recognized, which includes edge features, texture features, etc. The multiple features extracted from the image to be recognized are then compared with the object features extracted by convolutional neural networks through a large amount of training data. The multiple features extracted from the image to be recognized are then combined with the object features extracted from a large amount of training data by convolutional neural networks, and the objects in the image are then classified and defined. In the recognition process, the loss of details and blurring of contours in the low-light images make the apparent features of the objects in the images change greatly and cannot accurately reflect the original features, which eventually leads to a decrease in recognition accuracy[7].

4. Dark light imaging simulation

4.1.Brightness and contrast adjustment

Point operations are performed by changing the gray value of each point (i, j) of the original image and mapping the gray value of the cover to the new image and then outputting it. Suppose r is the gray value of the pixel at the original image (i, j), s is the gray value of the processed image (i, j), and T is Transform or Mapping. then the relationship can be expressed as s=T(r). Uniform darkening of the image can be achieved when T is a line over the origin with slope less than 1.

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Figure 1. Original image.

Figure 2. Post-processing image.

4.2.Noise simulation

Night imaging will produce a variety of noise, the two most common Gaussian noise and pretzel noise, through matlab internal functions, set the appropriate parameters to add the simulated noise. Salt & pepper noise with a noise density of 0.005, Gaussian noise has a mean value of 0 and a variance of 0.01.

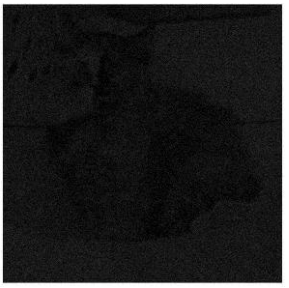

Figure 3. Gaussian only.

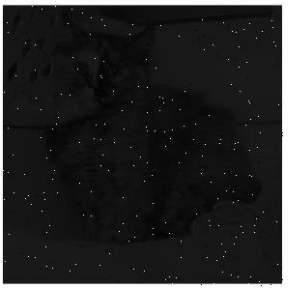

Figure 4. Salt & pepper only.

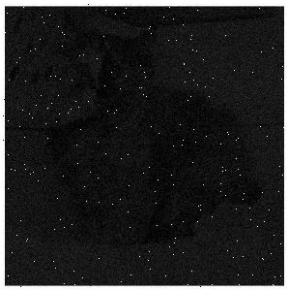

Figure 5. Gaussian and Salt & pepper.

4.3.Recognition probability

The recognition probabilities represent the various possibilities of the types of objects in the image to be recognized according to the model. The results are as follows.

Table1. Accuracy Comparison

Original image		**After Dark Light Processing**		**Gaussian and Salt & pepper**	
cats	*dogs*	*cats*	*dogs*	*cats*	*dogs*
0.94	*0.06*	*0.80*	*0.20*	*0.48*	*0.52*

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From the above results, it can be easily seen that for the original image, the model is able to classify the cat in the image well, and when the overall illumination of the image becomes darker, the model has a slight decrease in recognition certainty for the image, but it is still able to correctly identify it as a cat. When Gaussian and Salt & pepper noise are added, the model is no longer able to accurately distinguish the objects in the image between cats and dogs.

5. Image Enhancement Implementation and Results

5.1.Noise removal

Firstly, the Gaussian noise is filtered by Wiener filtering. The Wiener filter first treats the sum of the useful and noisy signals as the input to a linear filter, where the noise in the useful signal is a generalized smooth random process. [8]The parameters of the optimal linear filter can be calculated based on the minimum mean square error criterion knowing the second order statistical properties of the above two.

The Wiener filter is an adaptive minimum mean squared error filter. The method of Wiener filter is a statistical method, which uses the optimal criterion based on the respective correlation matrix of image and noise. For the filter, its smoothing effect shows a positive correlation with the local variance of the image, and the smoothing effect of the filter is also strong for images with large local variance, so the output of the filter can be adjusted based on the local variance of the image.

Formula

$$E\{[f(x,y) - f(x,y)]^2\} = \min$$

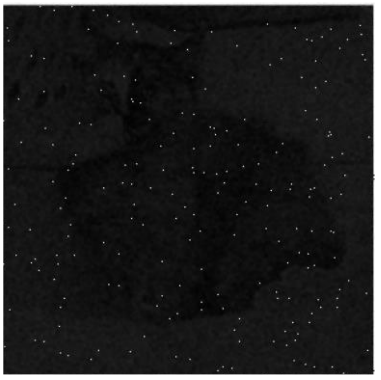

Figure 6. Wiener filtering effects, 3*3.

Next, the Salt & pepper noise present in the image is filtered out by median filtering. The median filter is a nonlinear signal processing filter. The statistical sorting method will be used in the filtering process. For pepper noise, we can think of the points that generate pepper noise as gray value anomalies that differ significantly from the gray values in the surrounding field. Median filtering takes the gray value of each pixel of the image and sorts them in order. [9]This acquisition area is called the template. For the two-bit median filter, the output is$g(x,y) = \text{med}\{f(x-k, y-l), (k,l \in W)\}$

where W is the two-dimensional template, the shape of the template can be customized, can be a circle, square, triangle and other arbitrary shapes, for more ideal output effect is generally used square, the size of 3 * 3, 5 * 5, 7 * 7 more commonly used. After collecting the grayscale values in the field, the filter calculates the median value of the grayscale values and assigns the median value to the pixel being processed, thus eliminating the noise in the image with abnormal grayscale values.

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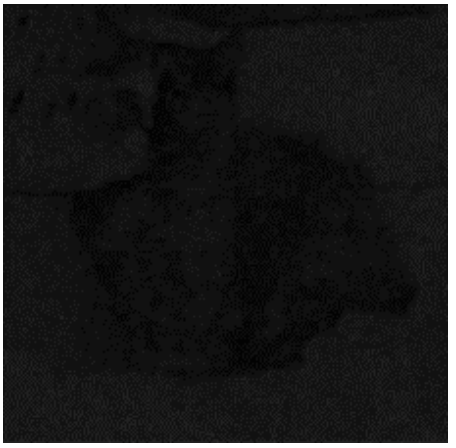

Figure 7. Median filtering effects,3*3.

Table 2. Accuracy after noise removal

cats	**dogs**
0.71	*0.29*

The noise of the image is removed to some extent by successively using two types of filtering, Wiener filtering and median filtering. From the perspective of the human eye, the purity of the image is much higher than before the filtering, and the outline of the cat and the general trend of color and texture can be more clearly identified. Importing the processed image into the model for image recognition, it can be seen that the recognition accuracy has improved by 20% compared to that before processing. Although there is still a difference of about 10% with the accuracy before adding noise, the cat's characteristics can be correctly recognized.

5.2. Contrast enhancement

As the contrast of the image becomes low due to reduced lighting, the contrast of the image is improved by the histogram equalization method. Histogram equalization is a method to enhance the contrast of an image. The main idea is to turn the histogram distribution of an image into an approximately uniform distribution, thus enhancing the contrast of the image. This effect can be clearly observed by the above figure where the black and white relationship is more clearly defined[10].

Figure 8. Histogram equalization effects.

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Table3. Accuracy after contrast enhancement

cats	dogs
0.72	*0.28*

6. Conclusion

Through the above experiments, it is found that the accuracy of image recognition in dark light environment decreases significantly. Among the reasons affecting the degradation, the decrease of contrast caused by insufficient lighting and the loss of some details make the accuracy have some degradation, when if the lighting conditions are not extreme, it is still possible to complete the general classification. In the face of noise, the accuracy of image recognition is significantly reduced, and it is not possible to strive for the extraction of features of the image. Gaussian noise can be well removed by Wiener filtering, while median filtering can mitigate the salt & pepper noise. After the images were processed by the two filters, the recognition accuracy had a high improvement, with a 20% improvement. In solving the problem of contrast ground, the image recognition accuracy did not improve significantly after using histogram equalization, but remained at the original level.

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