A Review on Gradient Histograms for Texture Enhancement and Object Detection

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Abstract - *Deblurring is the process of removing blurred artefacts from images, such as blur caused by defocusing of camera or due to motion of the subject. Image priors such as non-local priors of image gradient are used, which play an important role in image deblurring methods. Both local and non-local image priors improve noise and ringing artifacts while attenuating fine textures. To solve this problem, the algorithm based on Gradient Histogram Preservation (GHP) is used. Combining GHP model with non-local sparse prior constraint, the global and non-local sparse constraint will synthesize rich textures resulting in natural image. For the resulting image, feature extraction using the Histogram Oriented Gradient (HOG) algorithm is used for object detection. Due to their unpredictable appearance and the wide range of poses they can take, identifying objects in images is a challenging task. The problem of object detection is the feature sets that demonstrate locally defined Histogram Oriented Gradient (HOG) descriptors and also provides excellent performance relative to other current feature sets. HOG is stable, scalable, and effective in the extraction of features that operate on gradients between neighboring pixels. Using the Support Vector Machine (SVM), the extracted function is then classified.*

Key Words: Gradient Histogram Preservation (GHP), Non- locally Centralised Sparse Representation (NCSR), Histogram Oriented Gradients (HOG), Support Vector Machines (SVM).

1. INTRODUCTION

Image processing improves the pictorial information and also employs methods capable of enhancing the image information for human interpretation and analysis. It involves filtering of the noisy image and results in a filtered natural image which is better than the noisy image. Image gets corrupted when noise is added or when blur occurs. Blurring of the image occurs due to camera shake, movement of the subject, blurred background or mist and fog. Blurring is a type of ideal image bandwidth reduction due to imperfect image forming process. Blur can also be introduced by improperly focused lens or atmospheric turbulence. In order to remove the blur, many image deblurring techniques try to reverse the degraded image in order to recover the true image. Restoration often displays ringing artifacts and recovers missing components of the frequency. Deblurring is an iterative process that considers the different parameters for each iteration. This process will continue until the image received is based on the range of information which seems to be complete natural image.

Different image deblurring algorithms focus on developing appropriate regularizations to prevent the restored image approaching the sharp latent image. Such concepts of regularization are based on priors of natural image, such as gradient priors, non-local priors, and sparse priors. Priors are the image information that is used to define the natural image characteristics. To differentiate restored images from unnatural images, another classical sparse or non-local prior model is created. Nonetheless, most of the current image deblurring methods that leverage such regularizations can eliminate textures of mid-frequency while reducing image deblurring ringing artefacts and noise. Distinctions between priors result in the depiction of different natural image characteristics, and thus should work more effectively in combining different image priors on image deblurring.

Though the image is restored, there exists some variations in the intensity pixels called gradients and can be estimated through graphical representation called histograms, in which the number of intensity pixels can be calculated. Also, fine textures are attenuated during image deblurring. We use the gradient histogram preservation (GHP) model to address this issue, according to the intuitive thinking that the gradient of a well-reconstructed image should be the same as that of the original image. In this paper, we develop a texture-enhanced image deblurring algorithm (Gradient Histogram Preservation based Deblurring algorithm, GHPD) combining the GHP model with the non-locally centralized sparse representation (NCSR). The proposed denoising approach based on GHP can well boost the image texture regions, which are often over-smoothed by other denoising methods. A novel image denoising improved texture method is introduced, which retains the original image's gradient histogram. A gradient histogram preservation algorithm is developed using histogram specification to ensure the gradient histogram of the denoised image is similar to the reference histogram.

A new deblurring algorithm is introduced, in which we attempt to exploit the NCSR model's non-local similarity. Because of the homogeneity and randomness in an image between texture regions, the NCSR model will work well to eliminate noise and

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ringing artefacts resulting from deblurring, whereas GHP performs better on texture enhancement. The sparse prior is the most common gradient and NCSR model is one of this type, as stated earlier, this model-based deblurring approach can eliminate substantial mid-level textures considered to be noise or ringing artefacts. Image deblurring will inevitably result in some ringing artefacts and noise. Due to the degradation of the observed image, the sparse representations by conventional models may not be accurate enough for a faithful reconstruction of the original image. At the end, the image is exploited by means of nonlocal self-similarity to obtain good estimation of the sparse coding coefficients of the original image, and then centralize the sparse coding coefficients of the observed image to those estimation.

Object detection and classification are major techniques that are used in automated systems such as identification of persons, self-driving cars, face recognition for security applications, text identification, disaster management, medical imaging. Histogram Oriented Gradient is one of the common feature detection algorithms. HOG is famous for detecting the boundaries of the objects through gradient variation and the ability to classify varied pixels using linear SVM model. Dalal and Triggs developed HOG [5] that operated on an INRIA pedestrian dataset. From the data it had correctly identified humans. Gradient-based approaches have been an important area of research, and implementations are constantly being built in with more human accuracy. It employs descriptors of local features based on edge and gradient to define representation of the individual. It is easily controllable, translation and rotation invariant and produces good detection accuracies.

1.1 Feature Extraction

Feature is any quantifiable parameter obtained from an object in order to identify, analyze, describe and classify for a specific application. Features are descriptive points to be identified from an object. Attributes in image processing are usually corners, edges of an image object, regions of interest (ROI), and ridges. For object identification to be proficient, proper features has to be selected for identifying the objects. Features should be unique, distinct, measurable and should be able to capture relevant information and organize in an accessible manner for further reference.

Part-based approaches classify characteristics by splitting image into multiple parts and matching the loaded data set. Holistic methods identify an object which is viewed on a sliding window. Feature detection has been a key processing phenomenon to machine vision, deep learning, classification and text analysis. Some of the feature extraction algorithms are Harris corner detection, SIFT (Scale Invariant Feature Transform), SURF (Speeded-Up Robust Features), FAST (Features from Accelerated Segment), FREAK (Fast Retina Key point) and HOG (Histogram of Oriented Gradients).

2. Related Works

R. Fergus, B.Singh, A. Hertzmann, S. Roweis and W.T. Freeman[1] analyzed a method of removing the camera shake effects in photographs. By applying natural image priors, advanced statistical techniques and an extensively exploited natural images through heavy-tailed gradient algorithm, the possible results were obtained. These approaches were useful in reducing other computational photography problems.

The above approach resulted in few image variations. In order to remove these variations, L. Rudin, S. Osher and S. Fatemi[2] proposed a method of minimizing the overall image variation using gradient projection method. A limited number of algorithms for optimization is provided to extract noise from images. The overall picture variance is reduced to subject the restrictions that include noise statistics. It amounts in solving a partial differential equation that depends upon multiple of time defined by the constraints. The total variation of the image is minimized with respect to constraints that are imposed using Lagrange multipliers and hence resulted in a restored image.

W. Dong, L. Zhang, G. Shi and X. Li [3] developed a sparse or non-local model is developed to differentiate between restored images and unnatural images. For processing the image patches, one set of databases are selected to characterize the local sparse domain regions. Two adaptive regularizations are introduced into sparse representation framework. The first method is the autoregressive models which adaptively selects the regularizations in the image local structures. The second method is the image nonlocal self-similarity is introduced in another regularization term. The sparsity regularization parameter is estimated for better image restoration performance. Both the proposed method achieves much better results in both PSNR and visual perception.

To extract the corner feature points during object detection, Harris C. and Stephens. M [4] proposed Harris corner detection which identifies relevant feature points by employing a local detecting window on the image. Corners of an image show important information about the quality of the image where various edge directions meet. Corners are important feature points because translation and rotation of pixels are invariant. Moving a detection window and observing the change of intensity of pixels reveals the presence of an edge or corner.

Lowe and David G. [5] proposed SIFT algorithm which is a local and appearance-based method of extraction of features which is invariant to image scaling and rotation. Invariance to certain conditions is emphasized to define a robust distinctive feature for representing an object/image even with variations in lighting, noise and viewpoint. SIFT approach is a basic concept used in advanced techniques. SIFT performs well with small database in near real time efficiency.

Bay H., Tuytelaars T. and Van Gool L. [6] developed SURF algorithm which detects ROI points by an efficient algorithm which was developed by Bay for representation invariant to neighborhood points and correlation. Selection of feature points, obtaining a unique and robust feature to depict neighborhood and applying fast Hessian detector on coordinated descriptor vector for extracting the feature points are the processes through which the algorithm works. The uniqueness of SURF results in fast computation in feature matching points.

Rosten E. and Drummond T. [7] developed a FAST algorithm which is a corner detection method that uses segmentation of an image into circles of 16 pixels and pixel intensity variation can be identified across the borders of the circle. A segmented test is accelerated as the rejection of corner points that are fast and simple based on referral methods of some specified pixel points.

Vandergheynst P., Ortiz R and Alahi A. [8] proposed FREAK algorithm which is a binary matching descriptor that improves the efficiency of descriptor by using a set of non-overlapping concentric circular rings similar to retinal pattern. The Gaussian patterns around a point of interest are evaluated and the speed of this algorithm is better compared to existing algorithms such as SIFT and SURF.

Suard, F et al. [9] designed a method for pedestrian detection for automotive in night light through stereo infrared images in a single frame-based method. They have analyzed shapes based on the pixels classified using an SVM classifier.

Kobayashi, T et al. [10] used Principal Component Analysis based HOG to obtain a score, to be classified using linear SVM. PCA-HOG is preferred for its ability to reduces dimensions, cost and improves the detection performance.

3. HISTOGRAM ORIENTED GRADIENTS

HOG is a gradient based feature descriptor and most widely used object detection method known for its superior identification character based on gradients, classification of gradients based on frequency of occurrence (histogram) and selection of object category through support vector machines. The main application of HOG is pedestrian detection and has further extension to traffic sign detection, face detection, hand writing digit recognition, landmine detection, disaster management, biomedical imaging, etc. The histogram method for the directed gradients is as follows:

- Normalization of the captured image is performed for processing of intensity values extracted from three color planes (R, G, B planes).

- Gradient asset of each picture element relative to its neighbor points is calculated.

- Classification of gradient pairs along mutually perpendicular axes, x and y directions, into incidence segment frequencies implies as bins. A single 9 element vector is produced for every cell of 8 x 8 dimension.

- Any illumination on the classification accuracy can be avoided by generating blocks through cascading cells over which intensities are normalized.

- The blocks are taken across the detection window to result in a string of HOG descriptors.

- The descriptors are fed to an SVM classifier which analyses the data with predefined weights, studies the characteristics of the representative features and classifies the image as human or non-human.

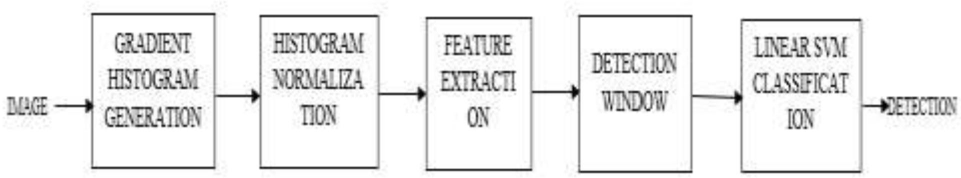

Fig -1: Overview of Histogram Oriented Gradient

The classification accuracy is defined using Detection Error Trade-off (DET) curves. Error curves provide a comparison of miss rate with the False Positives Per Window (FPPW) classified by the algorithm. Miss rate is the fraction of pedestrian cases that has been erroneously declared as non-pedestrians. False Positive per window is the parameter that describes the ratio of number of pedestrians that has been classified.

3. SUPPORT VECTOR MACHINES

SVM (Support Vector Machine) is a study system which uses linear functions as assumption space for high dimensional feature space. This arithmetic is already used in human face detection and identification successfully, and it still widely used in character, sound and others identification. Usually, linear SVM classifiers are used in conjunction with the HOG features for object detection. It is mainly used for classification and regression. The linear SVM is a representation of data amounts in which a nonlinear projection of data into a high-dimensional space where it is easier to separate the two categories of data of image. The radial basis function kernel, or RBF kernel is also known as Gaussian kernel, is a popular kernel function used for variety of applications. It is widely used in support vector machine classifier for classification of data.

4. CONCLUSION

In this paper, we proposed a gradient histogram preservation-based texture enhanced model for image deblurring. By constraint, the gradient histogram of the deblurred image approaching that of the reference image, the GHPD method can achieve a satisfactory deblurring results with enhanced fine scale textures. We also applied this method to deblur the blurred images and resulted in visual quality of the deblurred images. Furthermore, the GHPD method not only can be used for image deblurring, but also for image denoising and other image reconstruction tasks. The main contribution of this technique is to amplify the most significant features that describe particularly an object detection. The improved HOG feature represents image, which depicts the edge features of image and reduces the impact of illumination. The improved HOG method largely reduces computation and cost, consumption of energy and power and accelerates speed of detection and efficiency.

TABLE 1: COMPARISON OF RELATED WORKS

METHOD	FUNCTIONALITY	ADVANTAGES	DISADVANTAGES
[1] Heavy tailed gradient algorithm	Analyses the camera shake effects of the photographs	Reduces the additional photography problems	Results in pixel variation in the image.
[2] Gradient projection method	Minimizes the overall image variation and picture variances.	Total image variation of the image is reduced and resulted in a restored image.	Failed to differentiate between natural and restored image.
[3] Adaptive sparse representation selection	Analyzed the difference between natural and restored image.	Adaptively selects the image regularizations in the local sparse domain which resulted in both PSNR and visual perception.	Failed to detect the corners or the edge feature points of the image.
[4] Harris corner detection algorithm	Identifies the local corner feature points using detecting window.	Shows the important information of the image where various edge directions meet.	Resulted in the variation of the intensity pixels of the image.
[5] SIFT (Scale Invariant Feature Transform)	Extracts the image scaling and rotation features	Performs well in small database in near real time efficiency.	Varies in certain conditions like noise and viewpoint of the image.
[6] SURF (Speeded-Up Robust Features)	Detects the ROI points by fast Hessian detector.	Results in unique and robust feature extraction of the image.	Variation in the neighborhood points and correlation.
[7] FAST (Features from Accelerated Segment)	Corner detection of the segmented image into circles of 16 pixels.	Variation of the intensity pixel across the borders of the image.	Rejects the corner points that are simple based on different referral methods.

[8] FREAK (Fast Retina Key Point)	Uses binary descriptor by using a set of non-overlapping concentric circular rings similar to retinal pattern.	Provides good speed compared to SIFT and SURF and improves the efficiency.	Other feature descriptor patterns result in mismatching of the varied intensity pixels.
[9] Single frame-based method	Pedestrian detection in night light.	Analyses the shapes based on the pixels classified using an SVM classifier	Resulted in detecting only few pedestrians due to lack of brightness in an image.
[10] Principal Component Analysis based HOG	Analysis of object detection using linear SVM	Cost efficiency and improves the performance through PSNR and RMSE.	Reduces the dimensions of the object in an image.

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