Study of Neural Networks in Image Restoration

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Abstract

In this paper, the neural network algorithm was employed in the restoration of image. Here the motion compensation in image was viewed as an ANN (Artificial Neural Network) energy minimization problem, and the EHE criteria (Eliminating Highest Error) was selected as the optimization objection of reconstruction problem. With the actual situation in image, neural network was designed in continuous work-mode. Meanwhile, optimal solution was found by minimizing the energy function for the objective function. With some typical images, the algorithms above were experimented in computer. The result proved the efficiency of neural network in the processing of motion restoration.

Introduction

In photograph process, the digital images can be easily degraded for many reasons, which often causes a lot of inconvenient use!

In the real, Motion is one of the common reasons that the make the images degraded. For example, relative motion is caused between the camera and the object. All of the restoration steps are tend to facilitate researchers for many areas. Therefore it is significant to solve this problem in a correct and efficient way.

Classical Algorithms of Restoration

In the typical situation, the image degradation can be modeled by a linear blur (such as motion, defocusing, atmosphere turbulence), and sometimes an additive white Gaussian noise. And the degradation model is given as follows:

$$g = Hf + n \qquad (1)$$

where g , f , n represent degraded image, original image and addictive noise respectively, and H represents linear spatially invariant or spatially varying distortion .

With this suitable model and an optimality criterion, digital image restoration means to improve the degraded image to be the original one as close as possible.

The classical algorithms to recover the motion-degraded image include Wiener filter, constrained least square criterion, maximum entropy and so on. All of them can be basically divided into two kinds, time-domain algorithms and frequency-domain ones. Most of these time-field algorithms restore the degraded image by supposing the physical model of degradation, and processing the raw image with the opposite way, while the frequency-field algorithms restore the degraded image with an appropriate filter.

Many researches in image restoration techniques had focused on these two domains. Although many classical algorithms were proposed and once worked in vogue, there were still many problems to some extent.

On one hand, the Point-Spread Function (PSF) should be exactly known in advance for traditional image restoration methods. In fact, most PSF of degraded image can not been defined easily before processing. According to a partly relative PSF and little prior knowledge, the raw image can be just estimated from the degraded one.

On the other hand, image restoration is one of a class named ill-posed problem, and its morbidity cannot be solved well with the traditional or classical algorithms. So they are very hard to settle the problems of motion compensation. Some new methods are needed to process this kind of images.

Neural Network Algorithm

In the last several years, neural network theory, as a valuable tool for constrained optimization problems, has being proposed as new computational tools of image motion compensation. Because of its advantages such as parallel processing, self-adaptive function, and half-baked data process ability, neural network algorithms are superior to the traditional ones in many aspects.

The processing power of biological neural network's lies in a large amount of neurons linked with synaptic weights. Motivated by this, artificial neural network models attempt to achieve good performance via dense interconnection among many simple computational elements.

For several kinds of neural network models, Hopfield neural network is widely used in image restoration with its outstanding merits. As a result, image restoration technology based on the Hopfield network, not only makes mainly use of the network's advantage of solving optimization problems, but also its high performance and effectiveness.

A Hopfield Artificial Neural Network (ANN) model involves two major operations: broadcasting a value to a set of processors and adding all of their values. With Hopfield network's advantage of energy minimization properties, a common strategy for image restoration is to map the image error function of optimization problem into the energy function of a predefined network.

The objective function for image restoration problem is defined as follow:

$$E = E_r + E_s = \frac{1}{2}\|y - Hx\|^2 + \frac{1}{2}\lambda\|Sx\|^2 \qquad (2)$$

where y and x are the degraded image and the restorated one respectively, H is the blur matrix defined by the PSF, S is an operator like Laplacian one.

The Hopfield neural network model consists of n interconnected nonlinear devices (neurons). Interconnection weight $w_{ij}, i = 1,...,n, j = 1,...,n$ are associated with neurons i and j . Here a bias of the network or threshold term b_i is attached to each neuron. The state of network at time t is denoted

by $v(t) = (v_1(t), v_2(t), ...v_n(t))^T$, where $v_i(t)$ is the state of neuron i . Also, the state of a neuron at time $(t+1)$ is computed by

$$v_i(t+1) = G(\sum_{j=1}^{n} w_{ij} v_i(t) + b_i) \qquad (3)$$

Where $G(u) = 1, u \geq 0$ or $G(u) = 0, u < 0$.

With ANN technology, the image quality is great improved, and the ring effect is much released. However, through theoretic analysis of Hopfield neural network, two lacks can be found: the conditions of image restoration technology with Hopfield network should have known PSF, and there is none hypothesis of noise types in the network. In this situation, many modified Hopfield neural networks have been proposed.

Experiment and Results

In this paper, Hopfield neural network is applied into the image motion compensation to make the degraded images much clear and efficient. A classical image-cameraman with 256*256 is chosen. In MATLAB, some blurred images are simulated with different motion distance. Here the pixel numbers is used to stand for the relative motion distance: 0.1, 1, 5, 10pixels. The precise PSF can be obtained, and the experiments are carried out with Hopfield algorithm.

During the restoration of the motion image with Hopfield network, a question should be considered at first: the criterion selection. In this paper, the EHE (Eliminating Highest Error) criterion is chosen to make the network run much efficiently. The criterion is described as follows:

EHE criterion A: When the Hopfield network runs in sequential update mode, the only neuron to be updated at each step is the one whose back projection error is the highest in all the updateable neurons.[4].

By this way, motion compensation of image can be viewed as an ANN energy minimization problem, and the EHE criterion is selected as the optimization objection of reconstruction problem. Through mapping the objective function onto the energy function, a Hopfield neural network is designed in continuous work-mode. This mode can make the minimal point of the energy function match the optimization image well. Also an optimal solution can be found by minimizing the energy function.

In order to test noise effect of the algorithm, some additive white Gaussian noise is applied. Then these blurred images are simulated in MATLAB again.

Here are the results:

Firstly, some blurred images are simulated with relative motion distance. The simulation result is showed as the Fig.1.

Fig.1 *The simulated motion image cameraman with 10 pixels*

Secondly, the blurred image is restored with the Hopfield network. It can be seen in Fig 2 that the restored image's quality with Hopfield neural network is improved.

Fig.2 The restored image cameraman

From the figures above, it is seen that Hopfield network with the EHE criterion restores the motion image well when PSF is known. Also most of the details blurred by the motion can be clearly seen after the restoration.

Due to the PSF information can be obtained easily and correctly as the blurring process clearly defined before. For the sake of testing the effectiveness of the algorithm, the PSF types and parameters are roughly estimated for an image taken by a 25~30m/s camera.

The blurred image is showed as Fig.3:

Fig.3 The real motion image

According to the estimated PSF, the network designed before is used to restore the blurred image. The restored result is showed as Fig.4:

Fig.4 The restored image

Comparing with Fig.3 and 4, it can be seen that the details in Fig.4 is clearer than that in Fig.3, in spite of the details in Fig.3 very complex.

Conclusion and Expectation

The experiment results show that this restoration model is effective, and the process speed is fast.

Neural network models have great potential in areas of parallel, high computation rates. Therefore, although the current best network systems are far from human performance, the image restoration from a degraded record is still a good application for neural network.

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