The Application of Neural Network in the Technology of Image Processing

Weibin Hong, Wei Chen, and Rui Zhang

Abstract—**Nowadays, we make use of the digital quantity to store and recover the information of the continuous quantity. It often takes us relatively large storage space to store the information, and can't acquire as much information of the continuous quantity as possible, because the traditional sampling process can't acquire the information of the adjacent sampling points' relationship. This paper puts forward a new idea that it take advantage of the structure of the Neural Network to store the information of the continuous quantity, so that it can greatly reduce the amount of storage space and recover as much information of the continuous quantity as possible. This paper gives an example of the application of Neural Network in The Technology of Image Processing. It tells us how to store and recover the image with the structure of Neural Network as a stored medium. The result show that, in this way, we can acquire a clearer image than using the traditional method, and greatly reduce the storage space which is used to store the information of the originally continuous quantity.**

Index Terms—**Neural Network, Image, Reconstruction, Storage.**

I. Introduction

At present, in the process of converting continuous quantity into digital quantity, we often make use of A/D converter to complete the process of sampling, quantification and encoding [1]. Then we store the digital quantity in the storage medium. It's a method which is very simple and convenient. However, the information acquired through the traditional method, do not contain the information of the adjacent sampling points' relationship. As a result, it leads to the increase in the amount of storage space and the decline in the quality of information which we convert from the continuous quantity and store in the storage medium. In the following process of converting digital quantity into continuous quantity, the closer the output approximate to the original continuous quantity, the higher sampling frequency it requires, and the more storage space we need. However, if we use less storage space to store the information of the continuous quantity, the sampling frequency have to be low, in this case, we can't achieve an accurate output which is used to approximate to the original continuous quantity. As a result, the accuracy of the conversion and the storage space, which is used to store the information of the original continuous quantity, become the contradiction of today's technology. In face of the contradiction, we have to improve the converting quality, and the way in which we store the information.

The neural network has good performance in non-linear capacity [2]. It has proved that the multi-layer neural network can accurately approximate to any linear or nonlinear function. Through learning the incomplete data, the neural network can achieve an accurate prediction of the whole data with its generalization capability. We can utilize the neural network to approximate to the continuous quantity, because any continuous quantity can be express by the combinations of linear and nonlinear function. We can use the structure of the neural network to store the information of the continuous quantity. The new technology can help us solve the technical problem of clear visual communication and the problem of high compression ratio, etc.

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II. The Drawbacks of The Traditional Camera

In order to simplify the training of the neural network, we use a one thousand pixels camera to simulate our daily digital camera. Because one million pixels are far more than one thousand pixels, we use a one million-pixel map to simulate the continuous quantity object we day to day shoot with our digital camera. There is a one million-pixel map, just as Figure (1).We can regard it as a continuous quantity.

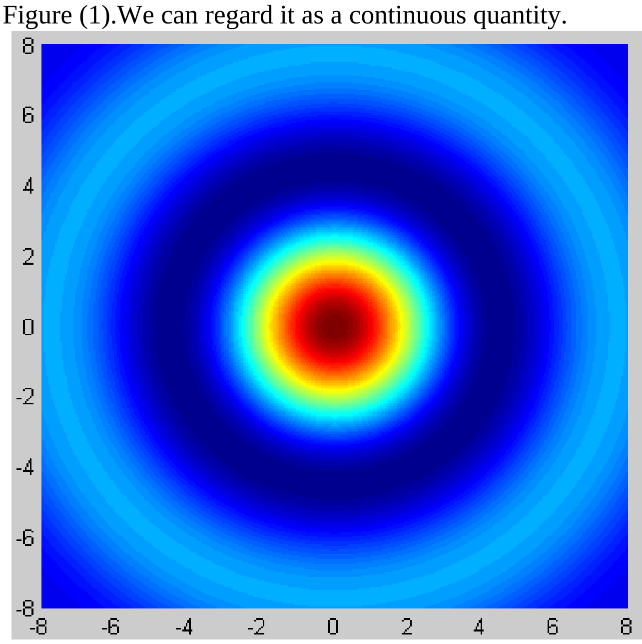

Fig 1.The map which is regard as the continuous quantity

The horizontal axis is X axis, and the longitudinal axis is the Y axis. The variable x, y range [- 8, 8] respectively. The map resolution is 1001×1001=1002001, one million-pixel map. The length of the map is 8×2=16 units, and the width of it is also 2×8=16 units. It means that there is a pixel every 0.016 unit in the X-axis (or Y-axis) direction of the map, namely x=-8:0.016:8; y=x, and every pixel with its own color. Then, these 1002001 pixels make up of this map. The pixel of the digital camera is 33x33=1089.Using this camera to take photographs of the map above, we can obtain a photograph with 1089 pixels, just as Figure (2). It's worthy to note that 1002001 pixels are far more than 1089 pixels. Thus we can regard the map with 1002001 pixels as the continuous quantity.

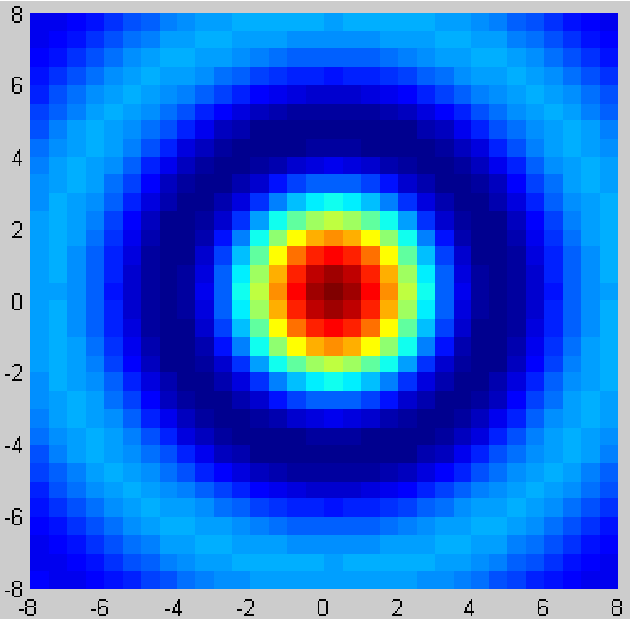

Fig 2.The photograph which is the traditional camera take.

In the figure (2), the horizontal axis is the X axis, and the vertical axis is the Y axis. The variable x , y range [-8, 8] respectively. The resolution of the figure (2) is 33 x 33=1089.The length and the width of the figure (2) are both 16 units. This means that there is a pixel every 0.5 unit in the X-axis or the Y-axis direction.

Figure (2), the photographs the digital camera take, turn up a lot of grids. There is one by one grid in the photographs. In addition, each grid has its own color. Further more, the photograph is blurred, and seriously lack of the sense of hierarchy. Many phenomena like this exist in our daily live. For example, when we zoom in our daily photograph, the phenomena happen. From this mosaic phenomenon above, we can see the drawback of making use of the digital quantity to record the information of the continuous quantity. Nowadays, the photograph we take is just like the figure (2), it take up a large amount of the storage space and can't obtain an ideal effect. If turning up the digital camera's resolution (for example, more than 5 million pixels), we can obtain a good visual effect at the expense of taking up a large amount of storage space (for example, 1 M memory).

III. INTELLIGENTIZE THE TRADITIONAL DIGITAL CAMERA

Embedding the advanced intelligent algorithms [3] into the traditional digital photo processing technology, it can greatly reduce the amount of the storage space, and greatly enhance the photograph resolution. The character of the neural network is that it can accurately approximate to any complex linear or nonlinear function. We establish a two-input and single-output neural network, whose two inputs are the abscissa and the ordinate of the pixel and the output is the color-level value. The network takes the information of digital quantity from the traditional camera as the study sample. After training, the structure of the neural network stores the information of the continuous quantity, which we use the digital camera to shoot. Through the network's generalization capability, we can obtain high-resolution image and store the image information in the form of the network's weight values, which take up less storage space than the digital quantity.

A. The visual effect realized by the new technology, which achieves the storage and the reconstruction of the image with Neural Network as a stored medium

(1)Define a range of color, just as figure (3), from dark blue to dark red in the range of [0, 1.2], and the color-level value is Z.

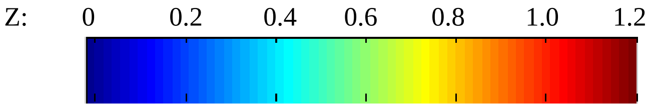

Fig 3.The color-level value

Then the Figure (1) can be seen as a three-dimensional graph. The color of each pixel in the figure (1) determines the color-level value z. The color-level value z, the abscissa axis (x) of the figure (1), and the ordinate axis (y) of the figure (1) determine the three-dimensional graph. If use the plane, which is determine by the x, z axis, to cut the graph, the graph appear as figure (4).

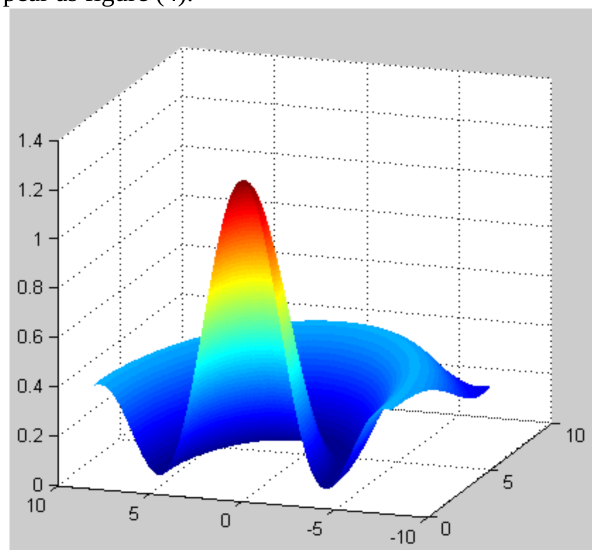

Fig 4.One half of the graph look like

Taking advantage of the neural network to approximate to the three-dimensional graph, it can obtain the information of the map as shown in figure (1). The X, Y are the inputs of the neural network and the Z is the output of it.

(2)Like the traditional method, after taking the photograph of the continuous quantity, the 33×33=1089 pixels camera stores the information in this way: It has 1089 pixels. Each pixel is stored in the form of X×Y×Z. For example 8×7.5×0.234, the 8×7.5 on behalf of the coordinate of the points, and the 0.234 is the color-level value. According to the Figure (3), it can know that this pixel is a certain blue. After taking photograph of figure (1), there are 1089 small data blocks in the form of X×Y×Z.

(3)Construct a neural network with two-input and single-output, in the Matlab Neural Network Tool - Graphical User Interface [4] just as figure (5).

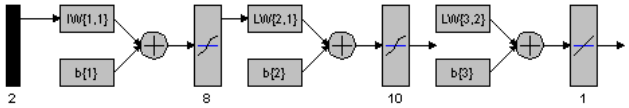

Fig 5.Build a neural network with two-input and single-output

(4)Train the neural network with the 1089 X×Y×Z data block. The X×Y is the input of the network, and the Z is the training target. Train the network 100 times. In the process of each time, it has to input 1089 coordinate value X×Y and the target color-level value Z [5]（-8.0×-8.0×0.0840，-8.0×-7.5×0.0912，-8.0×-7.0×0.0879……-8.0×8.0×0.0840，-7.5×-8.0×0.0912……8.0×7.5×0.0912,8.0×8.0×0.0840）.Then,the neural network store the information of the map through its own structure. In order to export the data block to the Matlab Neural Network Tool - Graphical User Interface(NNTOOL) as the training sample, it need to transfer the coordinate matrix X,Y into a matrix which include 2 row and 1089 arrange.

Program Ⅰ:

```
i=0.5;% define the step
n=8/I ; % calculate the number of the pixels in
          one - sided
x=-8:i:8;% calculate all the x
E=ones(2*n+1,1);% set up a matrix which include
                   2*n+1 row and 1 arrange
X=E*x;                    % Initialize all the abscissa
A=reshape(X,(2*n+1)^2,1);%Transform the matrix A into
                           a matrix which include
                           (2*n+1)^2 row and 1 column.
R=[1 0];
A=A*R;
y=-8:i:8;% Calculate all the y coordinate value.
y=y';% Transform the row vector into column vector.
Y=y*ones(1,2*n+1);%In order to prepare to import the
                    data blocks, it process the
                    longitudinal axis.
B=reshape(Y,(2*n+1)^2,1);%Transform the matrix Y into
                           matrix B which include
                           (2*n+1)^2 row and 1
                           column
R=[0 1];
B=B*R;
C=A+B;
C=C'; %  Merge the matrix A and B into a matrix which
         include 2 row and (2*n+1) ^ 2 Column,
         in order to train the neural network.
```

Program Ⅱ：

```
Z=reshape (Z, 1, (2*n+1) ^2);
```

Transform the color-level value, which is represent by the matrix Z, into the column vector.

(5)At the moment, it needs to reconstruct the continuous quantity, whose information is stored in the structure of the neural network above. Making full use of the generalization capability of the neural network, we export the new coordinate of the pixels (every 0.016 unit in the direction of the X-axis and the Y-axis respectively) to the input channel of the network. (-8.0×-8.0,-8.0×-7.984, …… -8.0×8.0,-7.984×-8.0，-7.984×-7.984……8.0×7.984,8.0×8.0).

Program Ⅲ: The same as the Program Ⅰ except to replace the i=0.5 by i=0.016. Then, export to the Matlab Neural Network Tool for simulation.

Export a total of 1001×1001=1002001 pixels to the input channels of network. In other words, create the image in the manner of one-million pixels although the network is trained by 1089 pixels information. For example, we export the coordinate data -8.0×-7.984 to the input channel of the network, then a color-level value z can be acquire from the output channel of the network. According to the figure (3), it can find the corresponding color to the value z. In this way, being imported 1001×1001=1002001 coordinate of the pixels, the neural network can calculate each pixel color. Then unite the 1002001 pixels, it can obtain a one-million image just as Figure (6). Although there is a certain error, Figure (6) is brilliant and the sense of hierarchicy is strong. The neural network calculates each pixel's color through its structure and generalization capability. It recovers each pixel as accurate as possible.

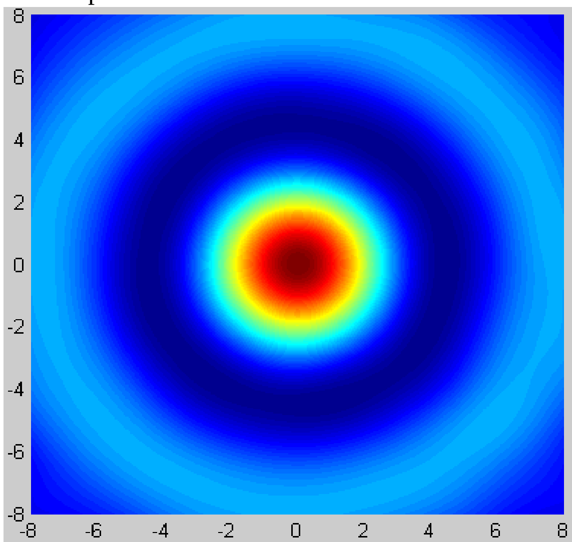

Fig 6. The image which is reconstructed by the neural network.

Image zoom, namely only display X, Y∈ [0, 8], just as figure (7). Even if we zoom in the image several times, there is not any grid in the image. The image is clear and has a strong sense of hierarchicy.

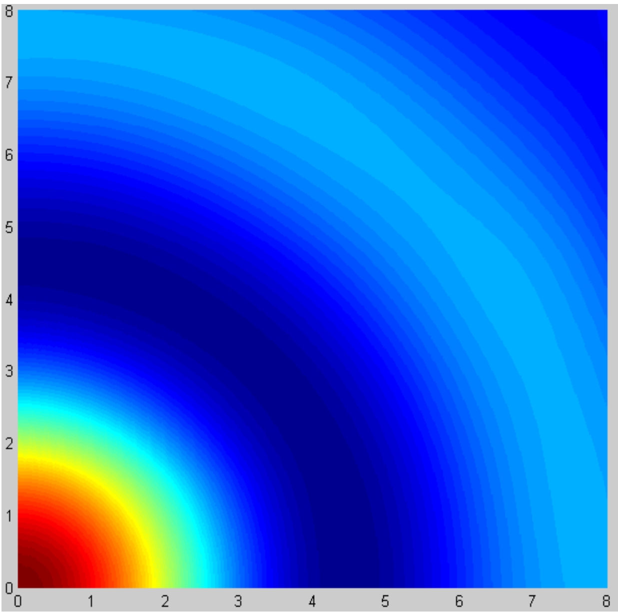

Fig 7.Zoom in figure (6)

If it changes the training step from 0.5 unit to 0.05 unit, the image will be further clearer, just as Figure (8).

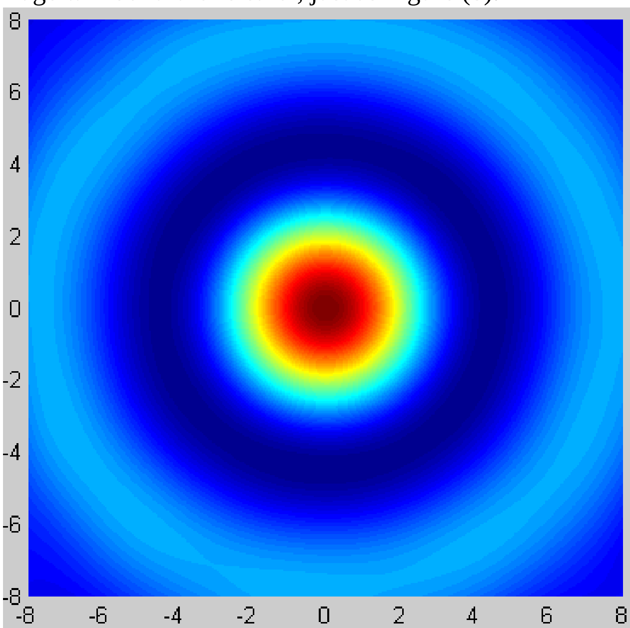

Fig 8. After changing the training step from 0.5 to 0.05, the image reconstructed by the neural network, further more close to the figure (1).

B. The storage mechanism, which take the structure of the neural network as a storage medium

In the way of taking advance of the neural network to store the information of the continuous quantity, if the camera and the display device both use the same network frame structure, what it only to do is to store all weight values in the network. We can calculate the color of each pixel from these weight values. The image can be obtained from these pixels. Indeed, the more information the continuous quantity contain, the more complex the neural network's structure has to be.

The weight value in the neural network above:

Iw{1, 1}-Weight to layer 1 from input1:（The weight values of the input layer）

[0.32117 0.23179; -0.22598 -0.058855; -0.2197 0.28916; -0.13236 0.23204; -0.12373 0.22589; 0.16722 0.17131; 0.012231 -0.34929; -0.28658 -0.24239]

Iw{2,1}-Weight to layer：(The weight values of the hidden layer)

[0.55072 0.49317 1.266 0.074822 -1.3834 -0.4892 -0.60075 -1.2118; 1.7877 -0.014468 -0.069213 -0.18165 0.8804 -0.36616 -0.10915 -0.55922; -0.51954 -1.6894 -0.080529 -0.85829 1.6584 -1.4344 -1.1693 0.21185; -0.22666 -1.6051 0.025461 -0.89101 0.3549 -0.42766 -0.29696 0.85384; -1.0715 -1.7215 0.30371 -1.3179 -0.15561 0.92942 0.14995 -0.012989; 0.16497 1.265 -0.79466 -0.20487 -0.71372 1.1138 0.75199 -0.58219; 0.73863 -0.69675 0.45287 -0.73209 0.64714 0.54201 -0.65613 1.3945; -0.56871 1.0983 -0.64282 0.18558 0.12391 -0.36618 0.47466 0.21524; -0.31446 0.24702 0.38106 -1.3354 0.54997 0.496 -1.4078 0.0042069; -0.93242 -0.81945 -0.56674 0.8288 -0.31064 1.3565 1.2404 0.96787]

Iw{3,2}-Weight to layer：(The weight values of the output layer)

[-1.0259 -0.37326 -3.0578 1.207 -0.24202 -0.82667 -1.1917 -1.2437 -0.66687 -1.438]

b{1}-Bias to layer 1:（The threshold of the input layer）

[-2.948; 0.71287; -2.3819; 0.80726; -0.75987; 0.61566; -1.8717; -2.4648]

b{2}-Bias to layer 2: (The threshold of the hidden layer)

[-1.9088; -1.5881; 2.3147; 0.048125; 0.30116; -1.2241; 0.97065; -0.95876; -1.0955; -1.4806]

b{3}-Bias to layer 3: (The threshold of the output layer)

[0.040692]

The amount of storage space, which is used to store the information of the continuous quantity with the structure of neural network as storage medium, is far less than the space which is used to store the same information with the digital quantity as storage medium.

It only takes up 1.12KB storage space in the format of txt to store the information of the network's weight values above. The image can be reconstructed through these weight values. However, it takes up 16.5KB storage space in the format of jpg to store the digital quantity in the camera.

IV. Conclusions

The new technology above, can achieve image storage and image reconstruction. In the cases of allowing some errors exist, it can obtain an image which is clearer, more sharp than the traditional digital image stored in the format of the digital quantity. It can also significantly reduce the storage space of the image. In a word, the new image processing technology, which take the neural network as a stored medium, can acquire as much information of the continuous quantity as possible, and can greatly reduce the amount of storage space.

The technology can efficiently compress the storage space of the information and achieve ideal result in the reconstruction. It is expected that the technology can resolve the high-speed, clear and smooth video wireless communicatory technical problem. In respect of the arithmetic speed of the current CPU, it can make full use of the technology to enhance the resolution ratio of the low-pixel image and the image whose effective pixels is declined as a result of image zoom. Also, the neural network can be also used to store the information of the MP3 and DV.

The sampling and the storage technology of the traditional camera, can only acquire the crude information of the continuous quantity. This traditional method, which is ‘breaking up the whole into parts’, lead to the increase in the storage space. It only stores the piecemeal details of the continuous quantity, and don’t contain any information of the adjacent sampling points’ relationship. As a result, it leads to the decline of the quality of the image reconstruction.

The neural network has the ability of storing the information of the continuous quantity. The detail information of the continuous quantity can be calculated from the whole network, and also determine the whole network. From now on, we can regard the neural network as the ideal storage medium for the continuous quantity rather than the digital quantity.

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