THE CONTEXTUAL HOPFIELD NEURAL NETWORK FOR
COLOR IMAGE EDGE DETECTION

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Abstract:
Edge detection is a very important preprocess for image processing research, we can decide the information about position, contours or size of the object by the features of image edge that detected by edge detection, and approach of pattern recognition and information retrial. But in general the edge detection methods, are required to manually select the parameters of an ideal edge to detect the edge, this method is not efficient.

This study used special gray-level conversion and Crimmins Speckle Removal as pre-treatment, and use of the Contextual-Hopfield Neural Network methods to unsupervised-learning methods to solve the problem manually select the parameters. Finally the use of voting to select the ideal edge imaging tests to assess the parameters of this study without the accuracy. The experiment proved that the method of unsupervised detection results can be similar to the edge of the ideal results.

Keywords: Edge detection ; Crimmins Speckle Removal ; Contextual Hopfield Neural Network.

1. Introduction
In image processing, edge detection is a very important pre-process. It can be applied to information retrieval, Image Segmentation, Pattern Recognition, and other fields. For example, what should have Zhihong and ground [1] scholars of the edge of the characteristics of objects, regardless of whether there is a graphic translation, rotation or scale zoom changes in circumstances able to successfully identify two overlapping objects. Information Retrieval, Jing Zhang and Seok-Wun Ha [2] academics, the use of images, representative of the edge, looking for library has the same characteristics of the image. In the application of image segmentation, Juan Li, Xian-Min Zhang [3] academics, the use of the edge detection methods, to find images of dynamic objects, and separated from.

These applications are needed to detect the edge as a pre-treatment in order to facilitate follow-up image processing for better results, so the edge detection can be said to be the lack of an image in a part of.

The choosing of these parameters is all by trial and errors to determine. It is not very efficient. Therefore, we quoted Zhang Yu Chuan [4] the Hopfield neural network, use no supervision of the learning method to solve the threshold set, and experimental verification of this study by the edge detection accuracy. System flow chart as shown in Figure 1.

Figure 1. System architecture map
2. Research Methods

2.1. Special Gray-Level Conversion

Edge detection of pre-processing is RGB feature vectors to the three groups after a gray-level processing, although this method can effectively reduce the overall structure and complexity of computing, but also give up hue, saturation, and other important source of information. In view of this, this study used special gray-level conversion method [5], this method compared to traditional gray-level conversion method, retain more of the original image information. This method of image in a more significant part of features, to give greater weighting value, then do regular treatment, so that after the conversion of the value between 0 and 255, the following formula:

\[
F(i, j) = R(i, j) \times \left(1 + \frac{\text{AmountR}(i, j)}{N}\right) + G(i, j) \times \left(1 + \frac{\text{AmountG}(i, j)}{N}\right) + B(i, j) \times \left(1 + \frac{\text{AmountB}(i, j)}{N}\right)
\]

It is a primitive picture element coordinate (i, j) respectively R, G, B value. AmountR(i, j), AmountG(i, j), AmountB(i, j) : Have it with the image (i, j) in R, G, B space respectively The total amount of image element of the same intensity, N: The total picture of the image is counted.

2.2. Crimmins Speckle Removal

The edge detection of the first steps are to consider the elimination of noise interference, and usually the use of low pass filter to filter out, but the edge and with a high-frequency noise, and the edge inevitably will be filtered out of fuzzy edge. We considered the above question, in Relevant adding Gaussian noise generated by the image sensor simulation of noise, Gaussian noise input parameters of the average of 0 and standard deviation of 0.01 set, noise ratio of 6 dB. Finally Crimmins Speckle Removal [6] can not only eliminate Gaussian noise interference, while also retaining the edge of the image, spot algorithms to eliminate steps. As shown in Figure 2, to consider each pixel in the image and the adjacent point of the eight pixels, respectively, on the whole image (NS, EW, NW-SE, NE-SW), and so do the following four directions deal with, first of all to consider (NS) direction, assuming the middle of three consecutive pixels associated with the neighbouring pixel size small, the increase in the middle of three consecutive pixels to remove dark points of noise interference. Instead, a decrease of three consecutive pixels of the middle row of pixels to remove the bright spots of noise interference. Then consider the other (EW, NW-SE, NE-SW), and other three points the direction of dark and bright spot noise to complete the first cycle of treatment, after several cycles, can be solved Gaussian noise interference. To NS (up and down), for example to illustrate, a, b, c representative of the up and down three consecutive pixels gray-level values:

\[
\begin{align*}
&\text{if } a \geq b + 2 \text{ then } b = b + 1 \\
&\text{if } a > b \text{ and } b \leq c \text{ then } b = b + 1 \\
&\text{if } c > b \text{ and } b \leq a \text{ then } b = b + 1 \\
&\text{if } c \geq b + 2 \text{ then } b = b + 1
\end{align*}
\]

3. Contextual Hopfield Neural Network

We consult the Contextual Hopfield Neural Network, CHNN method, the image directly into a structure the size of \(M \times N\) neurons formed the structure, considering all the pixels in the image with neighbors Domain pixels, each pixel point determine whether the edge point, and the use of 4th Runge-Kutta updated ways in which the CHNN can be gradual convergence of state stability.

3.1. Continuous Hopfield-Tank network

Continuous Hopfield network by Hopfield and Tank in 1984. Hopfield network through the energy function, so that high-energy network from the state at the minimum energy state, get answers to the convergence and stability is at the core of this network. Figure 2 through Continuous neural network model, to solve the best combination of artificial intelligence in the issue.

![Figure 2. Continuous Hopfield-Tank network Model](image-url)
N neurons the energy function, available under that type of differential equation:

$$\frac{du_i}{dt} = \sum_{j=1}^{n} W_{i,j} V_j - \frac{u_i}{R_i} + s_i$$  \hspace{1cm} (3)

Assumptions for a total of M samples of the output, the light of the above can be defined as: Assumptions for a total of M samples of the output, the light of the above can be defined as:

$$W_{ij} = \sum_{s=1}^{M} V_i^s V_j^s$$  \hspace{1cm} (4)

Neuron \(i\) input and the output relation down type of can show as:

$$V_{i} = f(u_{i})$$  \hspace{1cm} (5)

\(f(u_{i})\) defined as:

$$f(u_{i}) = \frac{1}{1 + e^{-\frac{u_{i}}{u_0}}}$$  \hspace{1cm} (6)

\(u_0\) is a constant, used to change the \(f(u_{i})\) steepness.

The Continuous Hopfield network systems in the energy function is defined as:

$$E = -\frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} W_{i,j} V_i V_j - \sum_{i=1}^{n} s_i V_i$$  \hspace{1cm} (7)

### 3.2. Energy function of design

In CHNN, the size of the image directly into the structure of \(M \times N\) neurons, the input for the special gray-level export and Output is the edge point of edge-based feature map. As shown below.

![Figure 3 CHNN structural chart](image)

In order to make CHNN can also consider each pixel point of the neighborhood pixels classification in order to determine whether each pixel point for the edge. CHNN the energy function must meet the following conditions: a non-border pixel gray-level value of the difference between the minimum. That is to say the least with the Euclidean distance, can be under-description:

$$d_{x,i,y,j} = \left( g_{x,i} - g_{y,j} \right)^2$$  \hspace{1cm} (9)

\(g_{x,j}\) Said pixels \((x, i)\) the value of pixels and the neighborhood function \(\phi_{x,j}^{p,q}(y, j)\) whether fell to \((x, i)\) as the center, respectively, to \(p\) for the horizontal direction of the radius, \(q\) for a radius of the vertical direction within the scope defined as follows:

$$\phi_{x,j}^{p,q}(y, j) = \sum_{l=-q}^{q} \delta_{j,l+1} \sum_{m=-p}^{p} \delta_{y,x+m}$$  \hspace{1cm} (10)

\(\delta_{i,j}\) defined as:

$$\delta_{i,j} = \begin{cases} 1 & \text{if } i = j \\ 0 & \text{if } i \neq j \end{cases}$$  \hspace{1cm} (11)

According to this definition, if pixel \((y, j)\) landed \((x, i)\) within the framework of the neighbouring regions, function value \(\phi_{x,j}^{p,q}\) of 1 or 0. According to Eq (5) conditions, we can define energy function as:

$$E = -\frac{A}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{(y,j)\neq(x,i)} d_{x,i,y,j} \phi_{x,j}^{p,q}(y, j) V_{x,j} V_{y,j}$$  \hspace{1cm} (12)

### 3.3. The equation is dynamic network

We Our definition of the energy function Eq (12) and continuous Hopfield network energy function Eq (7) network that can be compared after the weight value and the bias.

$$W_{x,y,j} = -\frac{A}{2} d_{x,j,y} \phi_{x,j}^{p,q}(y, j)$$  \hspace{1cm} (13)

and

$$s_{x,y} = 0$$  \hspace{1cm} (14)

We Eq (10) and Eq (11) into Eq (3), available \((x, i)\)
neurons in the importation of the following:

\[ Net_{x,j} = -\frac{A}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} d_{x,i,j} \phi_{p,q} y_{i,j} \] (15)

3.4. 4th Runge-kutta update algorithm

Decided to use a simple mechanism for judging the initial state of value, the value of this initial state will become the next state input and the value of iterative update, when the network after the convergence of the state at this time is the actual value of the best results. The equation is the dynamic network as follows:

\[
\begin{align*}
\frac{du_{init}}{dt} &= -\frac{u_{init}}{\tau} - A \sum_{j=1}^{n} d_{x,i,j,}\phi_{p,q}(y, j)V_{x,j} \\
V_{x,d} &= g(u_{x,d}) = \frac{1}{1 + e^{-\frac{u_{x,d}}{\theta_{x,d}}}} 
\end{align*}
\] (16)

In order to make the Internet to update weight faster and correct, this study used 4th Runge-kutta network update algorithms, through this initial set algorithms, and updated rules will update the weights more accurately. Algorithm as follows:

a. Initial set

\[ u_{init} = -\frac{u_{init}}{2} \ln(N - 1) \] (17)

\[ u_{init}^{t+1} = u_{init} + 0.1u_{init} \] (18)

\( u_{init} \) is the initial value of the network, N is the initial number of centres.

b. Update rules

\[ u_{init}^{t+1} = u_{init}^{t} + \frac{1}{6}(k_{1} + 2k_{2} + 2k_{3} + k_{4}) \]

\[ k_{1} = h \cdot f \left( u_{init}^{t} \right) \]

\[ k_{2} = h \cdot f \left( u_{init}^{t} + \frac{1}{2}k_{1} \right) \] (19)

\[ k_{3} = h \cdot f \left( u_{init}^{t} + \frac{1}{2}k_{2} \right) \]

\[ k_{4} = h \cdot f \left( u_{init}^{t} + k_{3} \right) \]

When the on-set up, then \( r_{3} \) is the turning point, the results are as follows.

3.5. Dynamic capture

We considered the network to update the results of the Histogram slope, when the non-edge approach will be part of a stable value, this study through the Histogram sharp rise in the turning point, and the turning point for the threshold. As part of the edge belongs to capture output results and methods are as follows, on a continuous consideration Histogram 5 point. \( r_{1}, r_{2}, r_{3}, r_{4}, r_{5} \) and \( x < y < z \), \( T \) is the threshold.

\[
\begin{align*}
x &= (r_{1} + r_{2}) / 2 \\
y &= r_{3} \\
z &= (r_{4} + r_{5}) / 2
\end{align*}
\] (20)

Figure 4. (a) Dynamic capture results (b) After the capture by the dynamic image

4 Experimental Results

We use the network provided by the test images, to select the mode of the image is divided into four main categories, and the use of Canny edge detection methods, all the tests to detect the edge of the image, and of voting methods to identify test images On the edge of the ideal, the final image of the ideal test will be marginal compared with oversight of this study to detect the edge of the results of this study was to verify the edge detection, can be a more visual senses similar to that of the edge c numbers. Table headings should be placed (centered) above the table. Place tables as close as possible to where they are mentioned in the main text.

4.1. Artificial Category

This study cited MD.Health [8] scholars put the image into four major categories, the Internet will be provided by the test image database [9], the authors selected from each
category classification of the 20 images, subjects were based on the author. By the selection of images, each category and then select 10 images, statistics by the authors after they were removed on the highest number of votes for each of the top five test images, as a test to detect the edge images, such as the classification results. The basis for the classification of different images as follows:

1. Natural objects, texture.
2. Natural objects, non-texture.
3. Man-made objects, texture.
4. Man-made objects, non-texture.

4.2. Artificial vote

We use of Canny edge detection algorithms to detect the edge image, enter the parameters can be divided into Low-threshold, High-threshold, three parameters, the author of selected parameters through to trial and error, the image detection test Edge, the final votes were measured by the way, every one of the test images selected seven of the visual senses to detect the edge, the author of Statistics is the highest number of votes in its ideal edge. Poll results to license plates, as an example.

![Figure 5. (a) original map (b) Ideal edge (c)Detection results](image)

4.3. Performance Assessment

We were divided into four categories there are 20 images, and each test images were of different natural images, using Pratt's figure of merit (FOM)[10] approach. Each category will be ranked first in each of the images, the method as follows:

\[
FOM = \frac{\sum_{i=1}^{N_s} 1 + a d_i^2}{\max(N_f, N_r)}
\]

Where \( N_f \) and \( N_r \) are the numbers of ideal and detected edge pixels, respectively. A denotes a penalty constant (often 1/9) used to penalize displaced edges. DI represents the distance between an alleged edge point and the nearest ideal edge pixel.

Each type of analysis of comparative data to each image as shown in table 1, FOM through the comparison of this study to know the daily life of common objects and the clear outline of the image edge detection to perform better, and no supervision of this study is the edge-detection methods and other research [9]. In comparison, the results show that this Research done without supervision edge detection methods may have similar oversight of the performance edge detection.

<table>
<thead>
<tr>
<th>Image Class</th>
<th>Rhine</th>
<th>Scorpion</th>
<th>Sunflower</th>
<th>Pigeon</th>
<th>Lotus</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural textures</td>
<td>4.861</td>
<td>3.7772</td>
<td>3.911</td>
<td>5.5705</td>
<td>5.8832</td>
<td>3.7416</td>
</tr>
<tr>
<td>Natural, non-textured</td>
<td>5.287</td>
<td>3.3354</td>
<td>3.9036</td>
<td>2.7542</td>
<td>3.7873</td>
<td>3.6618</td>
</tr>
<tr>
<td>Man-made textures</td>
<td>4.177</td>
<td>3.9452</td>
<td>3.5</td>
<td>9.4444</td>
<td>1.877</td>
<td>3.8768</td>
</tr>
<tr>
<td>Man-made, non-textured</td>
<td>4.939</td>
<td>3.8773</td>
<td>0.4461</td>
<td>1.8149</td>
<td>5.1535</td>
<td>0.718</td>
</tr>
</tbody>
</table>

Table 1 Performance evaluation.

5. Conclusions

This study used special gray-level conversion method, the special color images to gray-level conversion of space matrix, this method compared to traditional gray-level conversion method, retain more of the original image information, and cited the elimination spot to eliminate noise interference. At the same time can also retain the edge of the image, and through Contextual Hopfield neural network, select the parameters to resolve the issue and finally the use of motion capture methods, the output of the network edge as part of extract to detect the edge. And through this study of the experimental process of classification, the researchers detected after the edge of the image types, can have a profile of classified, and voted through artificial means to solve the edge detection accuracy, with a view to Benefit analysis of the effectiveness of algorithms.
References


