Research on Computer Multimedia Software Graphics and Image Processing and Analysis System in Colleges

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Abstract. With the development of computer software and hardware technology in colleges and universities, the application of multimedia computers has become increasingly widespread. Graphics and image processing occupy a major position in the application of multimedia computers in colleges and universities. Image display is the basis of image processing. The key of special effect display is to divide the image into different image area blocks. The usual image special effect display method is to divide the image into different image blocks according to certain rules. Based on the analysis of the principle of image special effects display, this paper proposes a template-based image special effects display method. Experimental results show that compared with traditional interpolation algorithms, such as bilinear interpolation and bicubic polynomial interpolation, this algorithm has better interpolation effects and overcomes the speckle interference in single wavelet interpolation.

Keywords: Colleges and universities, computer multimedia, single wavelet interpolation, multimedia software, image processing system.

1. Introduction

Natural images are one of the reliable ways that people often use to truly record events. However, with the development of computer graphics processing software, people have been able to draw computer graphics (CG) that are close to natural images through this software. Compared with natural images, these computer graphics can no longer be visually distinguished. This makes people want to use natural images to preserve the authority of the truth. Such forgery, if used in formal media, scientific discoveries, insurance, and court evidence, will have a serious impact on political and social stability. Therefore, the identification of natural images and computer graphics has become an urgent problem to be solved.

Image interpolation is a type of problem often encountered in digital image processing. The image resolution can be enhanced through interpolation, so it is widely used in medical images and optical remote sensing image resolution improvement. At present, traditional interpolation algorithms mainly include adjacent interpolation, bilinear interpolation, bicubic polynomial interpolation, and bicubic spline interpolation. The advantages of these algorithms are that the amount of calculation is small and the interpolation error is relatively small, but the image will often appear after interpolation. Block effect and detail degradation (blurred edges) phenomenon [1].
2. Principle of Multiwavelet Transform

For the tightly supported real function \( \phi_n(1 \leq n \leq r) \), if the vector function
\[
\phi(x) = \sqrt{m} \sum_k H_k \phi(mx - k) \quad (k \in \mathbb{Z})
\]
(1)

Then the vector function \( \phi \) is called the multi-scale function of the two-scale equation, \( r \) is the multiplicity of \( \phi \), \( m \) is the expansion factor, and \( H_k \) is the \( r \times r \) matrix. If there is \( \langle \phi(x), \phi(x-k) \rangle = \delta_{0,k} \), \( (1 \leq i \leq r, k, j \in \mathbb{Z}) \) then \( \phi \) is said to be orthogonal. If \( \phi \) constitutes a multi-resolution analysis on \( L^2(\mathbb{R}) \), and remember that \( V_j \) is the closure of the subspace stretched by \( \phi_{i,j,k}(x) = m^{i/2} \phi_i(m^j x - k) \), and \( W_j = V_j \setminus V_{j-1} \) is \( V_{j-1} \) the orthogonal complement space in \( V_j \), the definition of multi-resolution analysis shows that there is mutual positive The vector function \( \psi^{(s)}(x) = (\psi^{(s)}_1, \cdots, \psi^{(s)}_r)(1 \leq s \leq m - 1) \) that intersects and is orthogonal to \( \phi \), the function \( \psi^{(s)}_{i,j,k}(x) = m^{i/2} \psi^{(s)}_i(m^j x - k) \) \( (1 \leq s \leq m - 1, 1 \leq i \leq r, k, j \in \mathbb{Z}) \) expands into a subspace \( W_j \) and is a set of orthogonal basis on \( L^2(\mathbb{R}) \), so there is a matrix sequence \( G^{(s)}_k(1 \leq s \leq m - 1) \), so that the following formula holds
\[
\psi^{(s)}(x) = \sqrt{m} \sum_k G^{(s)}_k \phi(mx - k) \quad (1 \leq s \leq m - 1, k \in \mathbb{Z})
\]
(2)

And call \( \psi^{(s)} \) an orthogonal multiwavelet. For \( f(t) \in V_0 \), there is an expansion
\[
f(x) = \sum_{i=1}^{r} \sum_k c_{i,0,k} \phi_{i,0,k}(x) = \sum_{i=1}^{r} \sum_k c_{i,j,k} \phi_{i,j,k}(x) + \sum_{i=1}^{r} \sum_{j=1}^{m-1} \sum_k d_{i,j,k} \psi^{(s)}_{i,j,k}(x)
\]
(3)
\[
C_{j-1,k} = \sum_n H_{n,0} C_{j,n} D^{(s)}_{j-1,k} = \sum_n G^{(s)}_{n,m} C_{j,n} (1 \leq s \leq m - 1)
\]
(4)

And the reconstruction formula of one-dimensional multiwavelet transform (IDMWT)
\[
C_{j,n} = \sum_k H_{n,m} C_{j-1,k} + \sum_{s=1}^{m-1} G^{(s)}_{n,m} D^{(s)}_{j-1,k}
\]
(5)

For a two-dimensional signal, a multiwavelet decomposition is performed as follows: first, perform one-dimensional multiwavelet transformation on the pre-processed signal row by row, then perform pre-processing, and then perform one-dimensional multiwavelet transformation column by column to convert the two the dimensional signal is transformed into the multiwavelet domain [2]. Figure 1 is a schematic diagram of the second decomposition of the double two-band multiwavelet \( (r = 2, m = 2) \).
Each time the double two-band multiwavelet \( (m = 2, r = 2) \) decomposes the two-dimensional signal, the low-frequency part of the signal is further decomposed into low-frequency sub-bands and high-frequency sub-bands. For the data after multiwavelet transformation, use IDMWT for inverse transformation and carry out corresponding post-processing to restore the signal before transformation.

3. Realization of key technologies

3.1. Application management

Under normal circumstances, the application program has a tree structure. When designing, the complex program structure such as branching and looping is abstracted into logic control primitives. The program flow is regarded as the sub-branch of the logic control primitives, and the component objects form branch auxiliary primitives. The branch auxiliary graphic element composes the logical control graphic element, and the logical control graphic element itself is also a component, which can form a larger structure. In this way, a typical "part-whole" hierarchical structure is formed, and the combined model is adopted for design, so that the client area has consistency in the use of single objects and combined objects [3].

The key to the combination model lies in the abstract base class of the component object, here is the CImg-Tool class. Simple algorithm primitives and complex composite objects are derived from CImg-Tool. When designing, define the common operation interface of the combined object and the single object in the base class, such as the serialized interface function Serialize and so on. When implemented, the composite object calls the interface of its subcomponents, and implements interface operations through recursion. The primitive object derives from the CIMg Tool base class, and uses the base class pointer CIMg Tool* to manage it. The object-oriented polymorphism is fully utilized and the specific interface call is realized through dynamic binding. For pointer management, the MFC template class CTY pedptr Array is used to provide type safety guarantees for objects of the OBJet class or its subclasses, and to prevent errors caused by mismatched pointer types.

3.2. Traversal of the application

The data of the application is stored in the document class, which provides the corresponding interface for accessing the list elements to realize different traversal methods. The iterator mode is used to
separate the access and traversal of the list from the list object and put it into the iterator. Define the interface for accessing the list elements in the iterator class, responsible for tracking the current elements. The iterator class is tightly coupled with the list. Before instantiating the iterator, you need to provide the list to be traversed [4]. The pointer pList is used in the class to reference the list data. The First operation initializes the iterator and points to the first element; the Next operation pushes the current pointer one step further to point to the next element; the IsDone operation checks whether the traversal is over; the CurentItem operation returns the current element. The traversal algorithm is encapsulated in the iterator. Different types of iterators have different implementations. Take the full traversal iterator as an example. The first operation pushes the elements of m_Img-ToolList into the stack in turn; the Next operation determines whether the top element of the stack is a control primitive, if so, the current element is popped out of the stack, and then the auxiliary primitives in m_Branchs The element in the sub-component list m_Branch is pushed onto the stack, otherwise, the current element is directly popped.

3.3. Strategy mode realizes the reconstruction of the program tree

The document manages component objects through pointers. When rebuilding, the current pointer points to different types of objects, and the strategies for adding nodes are different. There are mainly three different node addition situations: ordinary algorithm nodes, auxiliary nodes, and control primitive nodes. Using the strategy mode, the method of adding nodes is encapsulated into a series of strategies. Strategies can replace each other, and the client area calls different strategies in the same way. The strategy pattern class is shown in Figure 2.

![Figure 2. Strategy pattern class diagram.](image)

Define a context class CInsert Item Context, use the strategy base class pointer m_pStagegy to manage the specific strategy class, and use the simple factory method to instantiate the specific strategy class in the constructor of the context class. For the basic strategy class CBaseInsertItem, when adding a node, if the parent node of the predecessor sibling node and the sibling node is not empty, then add it as the successor sibling node; otherwise, the current last node of the program tree is the parent node Add a new node [5]. For the logical node adding strategy C Logic Node Insert, first add logical nodes according to the CBaseInsertItem class, and then add auxiliary nodes and corresponding branches in turn. The auxiliary node addition strategy C Aux-Node Insert traverses the sub-component list of branch auxiliary primitives m_Branch, and then uses the C Insert Item Context class to add nodes in turn.
4. Multiwavelet image interpolation algorithm

4.1. The mathematical model of multiwavelet image interpolation

After pre-filtering the Gray image of size \( m \times n \) and performing multiwavelet transformation, 16 sub bands are obtained, of which there are 4 low frequency sub bands and 12 high frequency sub bands. The low frequency sub bands describe the smoothing information of the image, and the high frequency sub bands with detailed information of the painted image. Consider each sub band as an image, and its size is \( \frac{m}{4} \times \frac{n}{4} \).

Since the size of the original image is \( m \times n \) and the size of the high-frequency sub band is \( \frac{m}{4} \times \frac{n}{4} \), the problem of constructing the high-frequency sub band of \( \frac{m}{2} \times \frac{n}{2} \) can be transformed into the following mathematical model: If the image \( A = (a_{ij})^{m \times n} \) of size \( m \times n \) and the image \( C = (c_{ij})^{4m \times 4n} \) of size \( 4m \times 4n \) are known, where is The image reduced by 4 times under some mathematical transformation, find the image \( B = (b_{ij})^{2m \times 2n} \) after magnification 2 times or reduction 2 times.

\[
B = \begin{pmatrix} B_{11} & \cdots & B_{1n} \\ \vdots & \ddots & \vdots \\ B_{m1} & \cdots & B_{mn} \end{pmatrix}, \quad C = \begin{pmatrix} C_{11} & \cdots & C_{1n} \\ \vdots & \ddots & \vdots \\ C_{m1} & \cdots & C_{mn} \end{pmatrix}
\]

(6)

Where \( B_{ij} \) is the sub-block of \( 2 \times 2 \), \( C_{ij} \) is the sub-block of \( 4 \times 4 \), where \( 1 \leq i \leq m, 1 \leq j \leq n \), and \( C_{ij} = \begin{pmatrix} C_{ij}^{11} & C_{ij}^{12} \\ C_{ij}^{21} & C_{ij}^{22} \end{pmatrix} \), \( C_{kl}^{ij} \) are the sub-blocks of \( 2 \times 2 \), where \( 1 \leq k,l \leq 2 \). Let \( C_{ij} = \begin{pmatrix} C_{ij}^{11} & C_{ij}^{12} \\ C_{ij}^{21} & C_{ij}^{22} \end{pmatrix} \), where

\[
\overline{C_{ij}}^{kl} = \frac{1}{4} \sum_{k=1}^{2} \sum_{l=1}^{2} (C_{ij}^{kl})_{kk'}
\]

and let the standard deviation of each element of \( C_{ij}^{kl} \) be \( S_{ij}^{kl} \), then

\[
S_{ij}^{kl} = \sqrt{\frac{1}{3} \sum_{k=1}^{2} \sum_{l=1}^{2} [(C_{ij}^{kl})_{kk'} - \overline{C_{ij}}^{kl}]^2}
\]

(7)

Make

\[
S_{ij} = \begin{pmatrix} S_{ij}^{11} & S_{ij}^{12} \\ S_{ij}^{21} & S_{ij}^{22} \end{pmatrix}
\]

(8)

Suppose \( D = \begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix} \), take

\[
B_{ij} = \lambda_{ij} a_{ij} D + (1 - \lambda_{ij}) S_{ij}
\]

(9)

Let \( L = (\lambda_{ij})^{m \times n} \) ( \( 0 \leq \lambda_{ij} \leq 1 \) ) be the weight coefficient matrix, select the appropriate weight coefficient matrix, then \( A \) and \( C \) can be used to obtain the image \( B \) magnified by 2 times. If you
take \( \lambda_{\nu} \equiv 1 \), then \( E_B = a_y D = \begin{pmatrix} a_y & a_y \\ a_y & a_y \end{pmatrix} \) is equivalent to repeatedly magnifying \( A \) by 2 times. The value of \( \lambda_{\nu} \) is determined according to the characteristics of the original image. If the detailed information of the image is rich, the characteristics of the high-frequency sub band should be retained as much as possible, that is, the characteristics of \( A \) should be more obvious in \( B \), so \( \lambda_{\nu} \) should be larger. Otherwise, \( \lambda_{\nu} \) should take the smaller value.

4.2. Determination of the fractal dimension and weight coefficient matrix of sub bands in the multiwavelet domain

Let \( A \) be a bounded subset of \( R^n \), and \( N_\delta(F) \) is the smallest number of sets with the largest diameter \( \delta \) and covering \( F \), if the limit

\[
D = \lim_{\delta \to 0} \frac{\log N_\delta(A)}{-\log \delta}
\]

(10)

\[
\log N(r) = -D \log r + \log C
\]

(11)

Change the size of \( r \) to get a different \( N(r) \), and finally use linear regression to find the negative value of the slope of \( \log N(r) \) relative to \( \log r \). This value is the \( A' \) fractal dimension [6].

5. Simulation and Analysis

5.1. Experiment preparation

The experimental data comes from the natural image and computer graphics database of Columbia University. This library is usually used to evaluate the pros and cons of natural images and computer graphics authentication algorithms, and is widely adopted by scholars engaged in the research of digital image source authentication. This standard image library needs to be processed before the experiment to obtain the original image library and the image library with different noise characteristics. The steps are as follows:

1) The standard image library is not processed, and the image database is obtained. 2) Gaussian noise with a mean value of 0 and a variance of 0.02 is added to the images in the standard image library to obtain the image database 2. 3) The standard image library the image is saved as JPEG quality factor \( Q = 20 \), and the image database 3 is obtained.

5.2. Simulation results and analysis

The simulation running operation reads data from the document, parses out the logical structure of the application, and performs image processing. The simulation operating mechanism of the software is shown in Figure 3. The task list is traversed at the outermost level, and the control primitive sub-process is entered through the Process ( ) interface of the combined mode [7].
The Columbia University Natural Image and Computer Graphics Database has a total of 1600 pictures, including 800 natural images and 800 computer graphics. In the experiment, 2/3 of the image is selected as training (1066 images) and 1/3 as test (534 images). In order to reduce accidental errors, 10 experiments were performed respectively, and then the average value was calculated to obtain the detection accuracy (Accuracy). The experimental results of this paper are shown in Figure 4, Figure 5 and Table 1. In Figure 4, the abscissa is the serial number of the 534 pictures, the ordinate represents the predicted value, the green "o" represents the actual value, and the red "*" represents the predicted value. The result of one test that is closest to the average accuracy rate among the 10 discrimination results of the image database 1. It can be seen from the figure that the overlapping part of "o" and "*" is the image that is predicted correctly, and the isolated "*" represents the image that is predicted to be wrong [8]. There are four isolated points in the picture, which means that there are 4 pictures with wrong predictions, and all 4 points are CG (value -1) and mis predicted as photo (value 1). The statistical results of 10 experiments are shown in Table 1.

Table 1. Peak signal-to-noise ratio (dB) of different interpolation algorithms.

|                     | Lena  | Pepper | Elain  | Baboon | Couple | Sailboat |
|---------------------|-------|--------|--------|--------|--------|----------|
| Neighbour interpolation | 27.3824 | 24.4129 | 23.5784 | 18.8125 | 24.8561 | 23.9614  |
| Bilinear interpolation   | 30.5191 | 25.2290 | 24.3434 | 19.5173 | 27.0533 | 25.9336  |
| Bicubic polynomial interpolation | 32.1239 | 27.0735 | 26.1689 | 19.9531 | 24.8893 | 26.3334  |
| Multiwavelet interpolation    | 32.3267 | 30.8199 | 27.9171 | 24.0973 | 27.0835 | 28.1926  |

Figure 4. Forecast detailed results.
It can be seen from the above that the image feature quantity obtained by the method in this paper is 72 dimensions, which is only 1/3 of the colour image in literature. The experimental results show that this method has a strong ability to discriminate between natural images and computer-generated images. The accuracy rate reaches 99.1%, which is higher than the literature; because of the reduction of the feature quantity, the computational complexity of this method is reduced. Using the high-order cumulant of the data as the feature quantity, it can effectively combat the attack behaviour of Gaussian noise. It can be seen that the accuracy of image identification is still higher than 99% after adding Gaussian noise in the table; for the attack behaviour of JPEG compression, this method also has strong discrimination ability; accuracy rate is higher than 99%. The above shows that this method not only has a high identification accuracy rate, but also has a strong ability to resist attacks. In order to verify the stability of the method, that is, the prediction result is not affected by a random experiment, 10 experiments were carried out randomly. The experimental results are shown in Figure 5. In the figure, the abscissa (1-10) is the result of 10 experiments, and the abscissa (11) is the average of the results of the 10 experiments.

![Figure 5. Stability test results.](image_url)

6. Conclusion
The paper proposes a multi-wavelet image interpolation algorithm that is adaptive to the image itself. In the process of high-frequency sub band interpolation, both high-resolution images and low-resolution high-frequency multiwavelet coefficients are used at the same time, so the image after interpolation and amplification has rich details and clear edges, and overcomes the use of single wavelet transform. The speckle interference phenomenon when zooming in the image has a high signal-to-noise ratio. The experimental results also show that compared with the traditional interpolation algorithm, the effect of this algorithm is better. But at present, the values of all elements of the weight coefficient matrix in the algorithm are equal. How to make the value of the elements in the weight coefficient matrix change according to the characteristics of different positions of the image is the direction that the algorithm needs further research in the future.

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