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医学影像物理

# Mammography microcalcification detection based on clonal algorithm

CHE Lin-lin, ZHANG Guang-yu, LU Wen
School of Radiology, Taishan Medical University, Taian 271016, China

**Abstract:** Automatic detection of microcalcifications in breasts has become a hot issue in computer-aided diagnosis. Many detection methods have been put forward, but the positive detection rate and false positive rate of most of methods are unsatisfactory, without fully meeting the clinical needs. A new mathematical model of clonal algorithm was proposed in the paper. Based on the analysis and assumption on cloning technology, a new mathematical model was applied to extract microcalcifications, achieving high positive detection rate and low false positive rate. And the effectiveness of the algorithm has been proved by computer simulation results.

**Key words:** mammography; X-ray; microcalcification; clonal algorithm

## Introduction

Automatic detection of microcalcifications in breasts has become a hot issue in computer-aided diagnosis. Many scholars try to find a new effective algorithm which can improve the small calcification detection rate and reduce false positive rate. Many detection methods have been put forward, such as threshold classification, statistical classification, vector classification and neural network classification. Among these methods, neural network classification is the most effective and commonly used method.

Neural network classification has strong learning ability and fault tolerance. When the input signal is contaminated by noise, neural network classification can also achieve a good classification result[1]. Neural network input is the characterization of microcalcification's characteristics parameters which are on spatial domain or frequency domain, part or global. Cheng[2] proposed and studied on the characterization of calcification shape factors. Shape factors included compactness, moment and Fourier descriptor, etc, which could express roundness measurement results of varieties of calcification point shapes. The neural network was applied to classify and determine the location of microcalcifications. Yu[3] introduced the detection and classification which could detect microcalcifications automatically. The original image was firstly normalized, and then wavelet transform was used to remove high-frequency image noise and low-frequency background noise. Wavelet transform coefficients and the improvements of the standard deviation of image gray value were set as neural network input vectors. After microcalcifications were preliminarily located, the image features were extracted and optimized. The 31 selected feature vectors included compactness, grain, entropy, contrast, area and standard deviation. The optimized feature vectors were used as input signals, and the microcalcifications were accurately located by neural network classification.

## 1 Problems of existing algorithms and improvements

Although the automatic extraction algorithm of microcalcifications achieved certain results, the algorithm can't fully meet the requirements of clinical applications. Researchers studying on automatic extraction algorithms of microcalcifications aim to increase the positive detection rate and reduce the false positive rate by improving existing algorithms or using a new algorithm. In the past few decades, people simulated the biological genetic variation and evolution, proposing genetic algorithms and evolutionary algorithms, which have been widely used in practice. Cloning technology is the emerging science and technology in biology, achieving

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**Author:** CHE Lin-lin (1980-), MD, lecturer, research direction: biomedical signal processing, Tel: 15505486236, E-mail: llche@tsmc.edu.cn.

relatively satisfactory development and application[4]. The cloning technology was introduced and analyzed in the study. A clonal algorithm based on the simulation of animal cloning was proposed, and a mathematical model was established by the clonal algorithm for automatically extracting microcalcifications. The simulation results of the model were compared with the extraction results of the neural network to verify the validity of the mathematical model established by clonal algorithm.

## 2 Microcalcification detection based on clonal algorithm

### 2.1 Algorithm description

As shown in Figure 1, the interesting region was firstly inputted, and the characteristics of each pixel in the interesting regions were extracted to be the basis of chromosome coding in clonal algorithm, obtaining the initial activating factor. According to the description of the clonal algorithm in the literature[5], a new model of clonal algorithm was established, using the back propagation training method to obtain the optimal cloning algorithm activator. Finally, the clonal algorithm was used to extract the microcalcifications in the interesting regions[6-8].

### 2.2 Cloning technology and clonal algorithms

Organism cloning refers to the asexual reproduction, obtaining the organisms which were genetically identical with the original somatic organism. The organism cloning is the manual copy of organism.

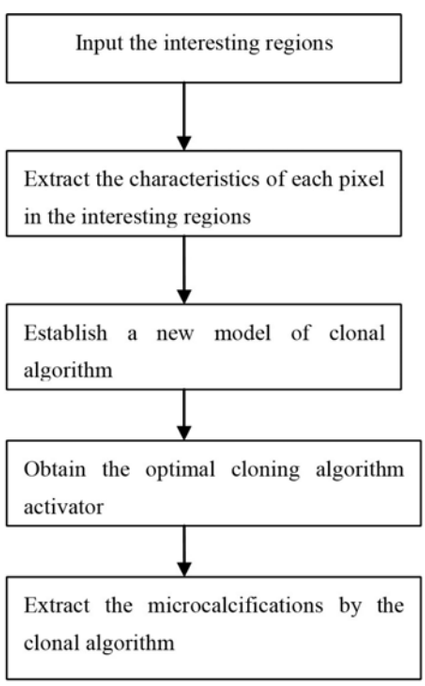



**Fig.1 Block diagram of the algorithm**

For plants, as early as the 1950s, people already had obtained a complete plant based on a single individual cell. Cells often mutates during the process of plant cell culture, so it is difficult to obtain the offspring which had exactly the same traits as the donor plant. Therefore, in the scientific community, these descendants are defined as regenerated plants instead of clonal plants. However, for animals, these descendants are called as clonal animals. In summary, cloning is the asexual reproduction of an artificial life conditions, or the life replication in the modern sense. From the perspective of genetic information expression, cloning is the re-expression of genetic information. During the cloning process, cells continue to divide and differentiate, and the cell function differentiates step by step. Cells change from pluripotency into single-function, and the genetic information is gradually carried out and expressed. From the view of biological evolution, cloning is the result of biological evolution reproduction, a microcosm of the biological evolution process. Moreover, biological evolution is an evolutionary process from simple to complex, from low-grade to high-grade. Biological evolution is the gradual process of biological optimization. Each existing organism is the local optimum during biological evolution. Clone only shows the result of the optimization. And the reproduction process is an optimization process. According to the cloning selection and taboo cloning phenomenon of the body, Li[9] proposed a clonal algorithm which was applied into the network structure clustering to obtain better results. Literature also proposed a different clonal algorithm for optimization function based on the analysis of the cloning technology and certain assumptions [5]. According to the different requirements of practical application, the algorithm could establish many different mathematical models[10]. Based on the principle of wavelet edge detection, a mathematical model was established by clonal algorithm for edge detection.

The substance of cloning is to extract the genetic information contained in animal somatic cells and fused with egg under the control of activator. After the continuous replication of chromosomes, the whole genetic information will be expressed by some optimal ways, because animal cells have the characteristics of pluripo-

tency, containing all of the genetic information of an animal body[11]. Eventually, the individual which is exactly the same with the original is cloned. Clonal algorithm is established on the analysis and the simulation of animal cloning.

The general idea of the clonal algorithm for breast microcalcifications detection was shown as the following. Each pixel in the interesting region of X-ray mammography was considered as a somatic cell of the animal. The genetic information of each pixel was extracted, and the chromosome coding was achieved based on genetic information, and the initial activation of factor was obtained based on the extraction of genetic information. After the continuous replication of chromosomes, the genetic information was expressed under the control of optimal activator[12]. The outward manifestation of the expression of genetic information was the rendering of animal features. The same species present the same characteristics, so different animals show different characteristics. According to the expression of genetic information, pixels of the interesting regions were classified, and microcalcifications were extracted. The paper also proposed a tical model of the clonal algorithm for automatically extracting microcalci fications. And the example of chromosome replication twice was applied to describe the mathematical model of the algorithm. The block diagram had shown in Figure 2.

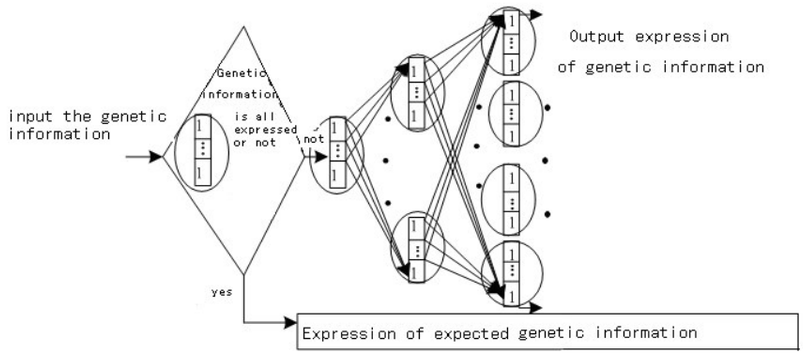



**Fig.2 Clonal algorithm**

### 2.3 Microcalcification detection based on clonal algorithm

The interesting regions were firstly inputted, and then the proposed method was used to extract the variance, mixture, and gray scale characteristics of each pixel. Based on the genetic information, chromosome coding could be achieved.

The extracted features were taken as the genetic information of initial activating factors, and the expression value of genetic information was obtained based on the formula (1). If the expression value was greater than the preset threshold, the desired genetic expression values would be outputted and this pixel would be extracted as microcalcifications. Otherwise, the chromosome would process the second copy, and the expression value of genetic information could be obtained based on formulas from (1) to (5). The optimal impact factor was obtained from training, and these values subtracted the genetic information of the desired expression value to obtain the absolute value. If the absolute value was less than the preset threshold, the pixel point would be the microcalcifications. Otherwise, the pixel was background. Based on the method, microcalcifications could be extracted by detecting each pixel of the interesting region.

$$E(i)=C(i)\Big/\left(1+e^{-v(i)}\right) \tag{1}$$

$$E(m,j)=C(m,j)\Big/\left(1+e^{-v(m,j)}\right) \tag{2}$$

$$v(m,j)=\sum_{i=1}^{N}w(m,ji)E(i) \tag{3}$$

$$E(k,i)=\sum_{m=1}^{2}C(m,ki)\Big/\left(1+e^{-v(m,ki)}\right) \tag{4}$$

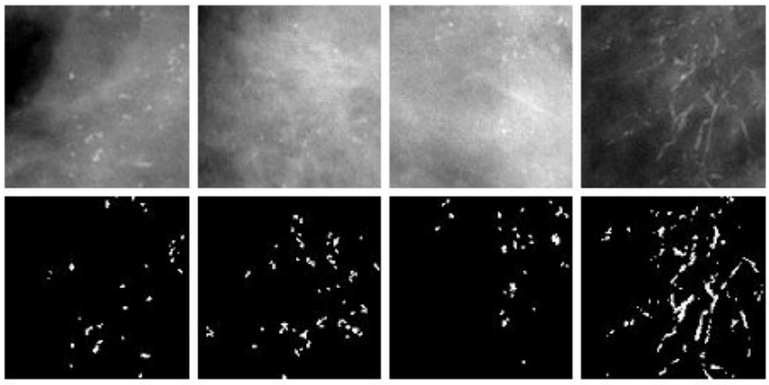
$$v(m,ki)=\sum_{j=1}^{N}w(m,kij)E(m,j) \tag{5}$$

## 3 Experimental results and comparison

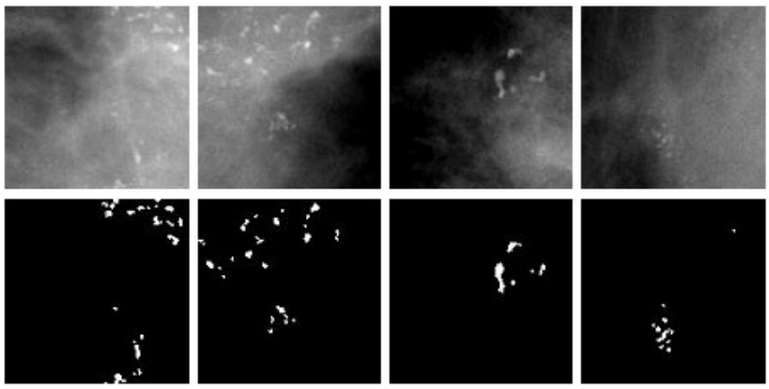
The 310 interesting regions of 50 cases and 100 images provided by Ji'nan cancer hospital and Shandong medical imaging research institute were detected by clonal algorithm. Some experimental results had been shown in Figure 3. The odd line was the original interesting region,

while the even line was the extraction result of the corresponding microcalcifications. The figure showed that microcalcifications were extracted completely by clonal algorithm. The same conclusion was drawn by detecting 300 interesting regions of 100 images from the database.

In order to evaluate the advantages of the clonal algorithm from the perspective of statistics, receiver operation characteristic (ROC) curve, the most popular method of diagnostic test evaluation, was applied to estimate the clonal algorithm. The 310 interesting regions and 7000 microcalcifications from the mammography image of 50 cases provided by Ji'nan cancer hospital and Shandong medical imaging research institute were selected. The ROC curve was drawn by changing the threshold value, as shown in Figure 4. Figure 4 showed that with the same false positive rate, the true positive detection rate of clonal algorithm was higher than that of neural network classifier.



**a: Image of the first line is the original one, image of the second line is the result of the extraction.**



**b: Image of the first line is the original one, image of the second line is the result of the extraction.**

**Fig.3 Extraction results of microcalcifications**

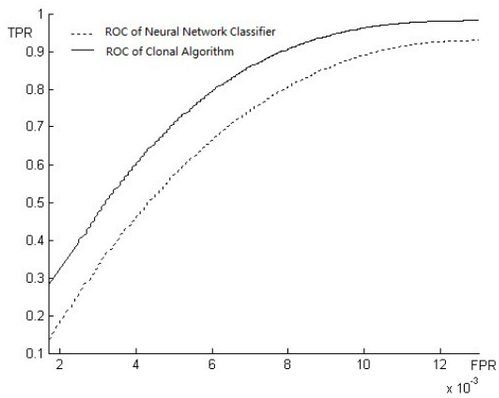



**Fig.4 ROC of neural network classifier and clonal algorithm**

ROC: Receiver operation characteristic; TPR: True positive rate; FPR: Fault positive rate

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# 基于克隆算法的乳腺X线影像计算机辅助诊断算法

车琳琳,张光玉,鲁雯
泰山医学院放射学院, 山东 泰安 271016

【摘　要】乳腺钼靶X线片微钙化点自动提取是乳腺图像处理中的热点问题。许多算法已经被提出,但由于阳性检出率低,假阳性率高,不能完全满足临床应用的需要。本文提出一种基于克隆算法的微钙化点自动提取方法,目的是获得高阳性检出率和较低的假阳性率。该方法基于对克隆技术分析和假设的基础上,模拟动物克隆过程,建立一种新的克隆算法数学模型。本文数学模型被用于乳腺钼靶X片微钙化点自动提取,取得较好效果。计算机仿真结果验证了本文算法的有效性。

【关键词】乳腺钼靶;X线;微钙化点;克隆算法
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【作者简介】车琳琳(1980-),硕士,讲师,研究方向:医学信号处理,Tel:15505486236,E-mail:llhe@tsmc.edu.cn。