MEDICAL IMAGE SEGMENTATION AND EXTRACTION BASED ON PULSE COUPLED NEURAL NETWORKS

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Abstract: Image segmentation is described as partitioning an image into a finite number of semantically non-overlapping regions. In medical applications, it is a fundamental process in most systems that support medical diagnosis, surgical planning and treatments. Generally, this process is done manually by clinicians, which may be time consuming and tedious. To alleviate the problem, a number of interactive segmentation methods have been proposed. Pulse Coupled Neural Networks (PCNN) is a self-organizing network that does not require training and the network was constructed by simulating the activities of the mammal’s visual cortex neurons. PCNN is unique from other techniques due to its synchronous pulsed output, adjustable threshold and controllable parameters. The visual cortex system of mammalians was the backbone for the development of PCNN. Cat’s and guinea pig’s visual cortex helped in developing some digital models. Image segmentation finds its best usage in medical applications. Medical image segmentation and extraction play a major role in detecting diseases or deficiencies and help doctor to make decision. MRI is a medical imaging technique, which uses magnetic fields and radio waves to form images of the body. Mankind would be benefited with this type of trained networks which help in segmenting images.

Keywords: Image segmentation, PCNN, Visual cortex, Small mammals, MRI.

1. Introduction

Image processing is a common term that covers image segmentation, image registration, image fusion, image thinning, image enhancement, edge detection, feature extraction, image recognition, noise removal from image, classification of images, texture and fabric defects identification, and surveillance[1,2]. Image segmentation is the process of partitioning a digital image into multiple segments [3].The goal of segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to analyse. Image segmentation is typically used to locate objects and boundaries in images [4, 5]. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

This research work uses pulse coupled neural networks for the segmentation and extraction of brain tumor from MR images. The visual cortex system of mammalians was the backbone for the development of pulse coupled neural network. PCNN is unique from other techniques due to its synchronous pulsed output, adjustable threshold and controllable parameters is hence the uniqueness of this network utilized in the fields of image processing [6].

Biological systems have always been an inspiration for developing algorithms. The mammal’s visual cortex formed the base of some network models. Cat’s and guinea pigs visual cortex helped in developing some digital models. The input information is received by the eye. Receptors within the eye are not sensitive to all the information. The sensitivity is based on colour, motion and intensity. The receptor after receiving the information alters the behaviour of surrounding receptors with respect to the contents and then forwards to the visual cortex and then the received information is analysed by the brain. The functioning of the visual cortex has to be studied in order to develop algorithms. Pulse coupled neural networks are unsupervised networks, in which the network is provided with inputs but not the desired outputs. The network is self-organized [7, 8].

This research paper is organized as follows. In Section II, the proposed pulse coupled neural network is described. Experimental results and analysis are presented in Section III. Finally, conclusions and discussions come in Section IV.
2. Proposed Pulse Coupled Neural Networks

Pulse coupled neural networks (PCNN) is a self-organizing network that does not require training and the network was constructed by simulating the activities of the mammal’s visual cortex neurons. The pulse coupled neural network is a two-dimensional neural network composed of pulse-coupled neurons. The PCNN neuron model consists of three parts: the receptive fields, the modulation fields, and the pulse generator are shown in the Fig.1.

Receptive field is the primary part to receive input signals from the neighboring neurons and from external sources and the field have two internal channels known as Feeding compartment F and linking compartment L. The linking inputs have faster characteristic response time constant when compared to feeding connections. The biased and multiplied linking inputs are multiplied with the feeding input to produce the total internal activity which constitutes the Linking or Modulation part. Finally the pulse generator of the neuron consists of a step function generator and a threshold signal generator. The neurons in the network have the ability of responding to stimuli. This response is known as firing. This firing is enabled when the internal activity of the neuron exceeds a certain threshold. The neuron output Y is set to 1. Now the threshold starts decaying until the next internal activity of the neuron. The output of the neuron is then iteratively fed back with a delay of single iteration. The output of the neuron is consequently reset to zero when the threshold is larger than the internal activity U. PCNN neurons produce temporal series of pulse outputs after n number of iterations. The pulse output carries information about the input image. The decision on the content of the image is achieved by examining the pulse output of the network. Feeding input and linking input communicates with the neighboring neuron through the synaptic weights. Input stimulus is given only to the feeding compartment. The neuron is receiving the input stimulus, which is its corresponding pixel’s colour information along with the neighbours in both the compartments. The flow diagram of PCNN algorithm is shown in the Fig.2.
3. Experimental Results and Analysis

A large data set consisting of a number of MR tumor images has been collected. Their MRI scans were stored in database of images in JPEG format. The technique developed in this research work is tested on a large database consisting of 60 tumor images [11]. Fig.3 shows the tumor extracted from MR brain images. The tumor portion of the MR image is visible, shown as white color. This portion has the highest intensity than other regions of the image. The algorithm proposed in this work is able to extract the brain tumor successfully.

On the other hand, various texture and shape based parameters of the MR Images are extracted and essential for further analysis. The parameters used for this purpose and their importance are as follows.

**Area:** Calculating the area of a black and white image gives the number of on pixels in the image. An on pixel means a brighter pixel which corresponds to a value of 1 in the image. If a MR image shows the presence of a tumor it shows it as a white mass.

**Mean:** The mean of a region gives the average intensity of the pixels in that region. A higher mean can indicate the possibility of small regions with concentrated bright pixels.

**Skewness:** Skewness is a measure of the asymmetry of the data around the sample mean. If skewness is negative, the data are spread out more to the left of the mean to the right. The skewness of the perfectly symmetric or normal distribution is zero. Skewness is measured from the histogram plot of the MR image.

**Entropy:** Entropy is a statistical measure of randomness that can be used to characterize the texture of the input MR image. It helps to measure the degree of randomness of the image intensities.

**Standard Deviation:** Standard deviation is a measure of average contrast of the MR image. Higher contrast indicates that tumor present in the MR image.

The comparison of parameters which are extracted from the normal and abnormal MR Images is tabulated in Table 1. The results from the table give us the hope to identify the MR image with Tumor. Each of the parameters is important in their own way. Since, each human has different characteristics, a standard cannot maintain for the parameters. Therefore a decision cannot be made based on any one of the parameters alone. The calculated values of all the parameters are processed together to decide whether a MRI is normal or tumor containing. It can be concluded that different parameters of first MR image is less as compared to the remaining images. So, the first MR image is normal and the remaining images contain tumor.
Table 1. Comparison of Parameter

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>MR Image</th>
<th>Area</th>
<th>Mean</th>
<th>Skewness</th>
<th>Entropy</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image1.png" alt="MR Image" /></td>
<td>80.25</td>
<td>32.52</td>
<td>9.39</td>
<td>4.90</td>
<td>41.08</td>
</tr>
<tr>
<td>2</td>
<td><img src="image2.png" alt="MR Image" /></td>
<td>332.51</td>
<td>46.64</td>
<td>13.61</td>
<td>5.97</td>
<td>54.20</td>
</tr>
<tr>
<td>3</td>
<td><img src="image3.png" alt="MR Image" /></td>
<td>274.80</td>
<td>118.47</td>
<td>15.77</td>
<td>7.10</td>
<td>83.76</td>
</tr>
<tr>
<td>4</td>
<td><img src="image4.png" alt="MR Image" /></td>
<td>171.11</td>
<td>64.89</td>
<td>15.49</td>
<td>5.65</td>
<td>77.16</td>
</tr>
</tbody>
</table>

Fig. 3. (a) Original MR Image (b) Tumor detected as white portion (c) Brain Tumor extraction
4. Conclusions

The pulse coupled neural network is unique since each neuron of the PCNN represents image pixel from the input image to be processed. The network is also powerful, if the parameters are tuned properly. The flaws, information retrieval from the images, diagnosis of cracks or abnormalities from X-ray images, tumor detection from MR images, CT images, and removal of noise from images proves the importance of PCNN in medical field. Generally the widely used segmentation algorithms used for image processing have some common disadvantages like computational costs and more time consumption due to certain features of images. Those disadvantages are overcome by pulse coupled neural network. This paper presented the pulse coupled neural network based image segmentation technique to extract brain tumor from the MR images and identified brain tumor successfully. The experimental results show that the proposed approach is much more efficient than the usual approaches.

References


Biographical Notes

Dr. J.Mehena is presently working as Professor and Head in the Department of Electronics and Telecommunication Engg., DRIEMS, Tangi, Cuttack, Odisha. He has more than 16 years of teaching and research experiences. He received his M.Tech in Electronics Engg. From Visvesvaraya National Institute of Technology (VNIT), Nagpur and Ph.D. in the area of Digital Image Segmentation. He has published 15 research papers in national and international journals. His areas of interest include Digital Image Processing, VLSI Design, Digital Signal Processing, Microprocessor and Microcontroller. He has authored 6 books to his credit. He is a life member of the Indian Society for Technical Education (ISTE) and Member of Institution of Engineers (MIE).

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