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STUDY OF FUSIFORM GYRUS OF BRAIN REGION IN MODELING AUTISM USING ARTIFICIAL NEURAL NETWORK

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Abstract

In the present work, fusiform Gyrus (FG) of brain region has been studied, as many researchers have the opinion that autism is a neurological disorder of the brain. From various researchers, it has been observed that abnormalities in face perception are a core feature of social deficits in autism. The FG along with other cortical regions are responsible for face processing tasks in controls are hypoactive in patients with autism. Recently, through functional magnetic resonance imaging (fMRI), it has been observed that neurons in FG are fewer and smaller in patients with autism. In the present approach FG of brain region has been studied to analyze autism employing artificial neural network (ANN). As FG is responsible for face perception, the images of the whole faces are considered to be the input image. The images of faces are acquired and converted into gray scale images, which in turn, transformed into binary form. The produced binary information are fed into the backpropagation network (BPN) for learning. In this study the algorithm of backpropagation network has been implemented employing C++. The number of face images, size, learning rate, input and output neurons have been considered as 4, 50X50 pixels, 0.5, 2500, and 2 respectively, in the present BPN. At the time of train the network, the hidden neurons have been varied to observe the learning pattern of the FG for different set of input images. It has been observed that the learning pattern improved as hidden neurons increased for different input images. When neurons in the network increased, the face processing tasks of patients with autism seems to be normal. These results also justify the observation of fMRI for the autistic patients.

Keywords

autism; fusiform gyrus (FG); backpropagation network (BPN); functional magnetic resonance imaging (fMRI); artificial neural network (ANN).

Introduction

Autism is a potential threat to the present world. A great number of individuals in the world have been suffering from autism. Some studies indicate that one in every 300 newborn babies is autistic, and others estimate that one in 166 has autistic behavior. Different studies give different estimates but all studies show that this number has continued to increase. It is a non-curable developmental neural disorder that is characterized by a triad of deficits, such as, i) impairment of verbal and nonverbal communication, ii) impairment of social interaction, iii) lack of imagination, and presence of restrictive and repetitive disorders. The specific causes of autism have not yet been known, and there is no medication for it. As a result, an autistic boy/girl faces innumerable problems since s/he begins to suffer from it. These children, because of their shortcomings, are never sent to any school belonging to the mainstream education of the country. Since there is no medication of autism, it is prime importance to understand the biological aspects of autism for its remedy.

A key feature of normal social functioning in humans is the processing of faces, which allows people to identify individuals and enables them with the capacity to understand the mental state of others [1]. Although not included in the current diagnostic criteria, patients with autism have marked deficits in face processing [2]. As such, alterations of this crucial skill for social interaction may represent a central feature of social disabilities in autism [3]. Imaging studies have provided evidence for a role of temporal lobe structures in face processing. It is well recognized from functional magnetic resonance imaging (fMRI) studies that the fusiform gyrus (FG) is consistently active when normal humans view faces [4]. Patients with autism can perform face perception tasks [5] but there is strong evidence that the FG, as well as other cortical regions supporting face processing in controls, is hypoactive in patients with autism [4][6][7]. However, the neurobiological basis of this phenomenon remains unknown [8][9][10].It has been proposed that the failure to make direct eye contact may explain the observed hypoactivation of the FG in face perception tasks in autism [11].

To model autism the face processing tasks of FG in patients with autism has been carried out using Backpropagation Neural Network (BPN).

Fusiform Gyrus

The Fusiform gyrus is part of the temporal lobe in Brodmann Area 37. It is also known as the occipitotemporal gyrus. Fig.-1. illustrares the FG of brain region.

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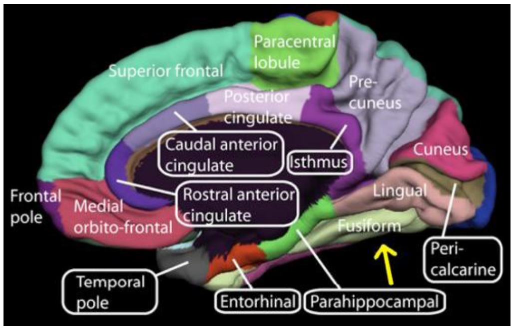

Fig 1. Fusiform Gyrus[12].

The FG has five layers namely II, III, IV, V, and VI depicted in (Fig.-2) [13].

- Compared to the controls, the patients with autism had a significantly reduced mean total neuron number in layers III, V, VI of the FG compared to the controls.
- The patients with autism had a significantly reduced mean total neuron number in layers III, V, and VI of the FG compared to controls.
- In layer III, the reduced mean total neuron number reflected a combined reduction in the mean volume of this layer as well as the mean neuronal density within this layer.
- In contrast, the reduced mean total neuron number in layers V and VI reflected mean volume of these layers rather than a reduced mean neuronal density within these layers.
- In addition, the patients with autism showed a significantly reduced mean perikaryal volume of the neurons in layers V.

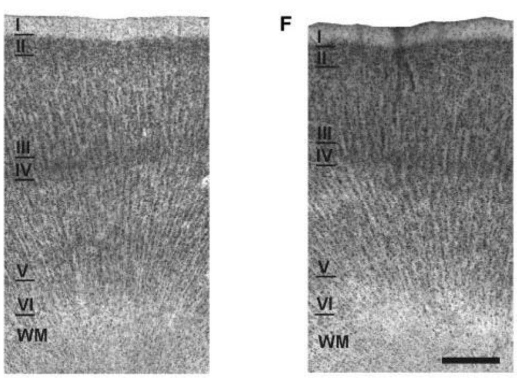

Fig 2. The Fusiform Gyrus layers of control patient and a patient with autism [13].

Research has shown that the fusifomr face area, the area within the fusiform gyrus, is heavily involved in face perception. Fusiform gyrus has also been involved in the perception of emotions in facial stimuli. Some functionalities of this area include [13]:

- processing color information
- face and body recognition
- word recognition
- number recognition

Backpropagation Network

Backpropagation is a common method of teaching artificial neural networks how to perform a given task. It was first described by Arthur E. Bryson and Yu-Chi Ho in 1969, but it wasn't until 1974 and later, through the work of Paul Werbos, David E. Rumelhart, Geoffrey E. Hinton and Ronald J. Williams, that it gained recognition, and it led to a "renaissance" in the field of artificial neural network research [14]. It is a supervised learning method, and is a generalization of the delta rule. For better understanding, the backpropagation learning algorithm can be divided into two phases: propagation and weight update.

Phase 1: Propagation

Each propagation involves the following steps:

- Forward propagation of a training pattern's input through the neural network in order to generate the propagation's output activations.
- Backward propagation of the propagation's output activations through the neural network using the training pattern's target in order to generate the deltas of all output and hidden neurons.

Phase 2: Weight Update

For each weight-synapse:

- Multiply its output delta and input activation to get the gradient of the weight.
- Bring the weight in the opposite direction of the gradient by subtracting a ratio of it from the weight.

This ratio influences the speed and quality of learning; it is called the *learning rate*. The sign of the gradient of a weight indicates where the error is increasing, this is why the weight must be updated in the opposite direction.

Repeat the phase 1 and 2 until the performance of the network is good enough.

Algorithm

Basic Algorithm Loop Structure

Initialize the weights

Repeat

    For each training pattern

        "Train on that pattern"

    End

Until the error is acceptably low

Detailed Algorithm

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Step 1: Foward Propagation

- Compute net_i and y_i for each hidden node, i=1,..., h:

$$net_i = \sum_{r=1}^{n} w_{ri} x_r \quad and \quad z_i = f_1(net_i)$$

- Compute net_j and y_j for each output node, j=1,...,m:

$$net_j = \sum_{i=1}^{h} w_{ij} z_i \quad and \quad y_j = f_2(net_j)$$

Step 2: Backward Propagation

- Compute ´2's for each output node, j=1,...,m:

$$\partial_{2j} = (t_j - y_j)\, f_2'(net_j)$$

- Compute ´1's for each hidden node, i=1,...,h

$$\partial_{1i} = f_1'(net_i) \sum_{i=1}^{m} w_{ij} \partial_{2j}$$

Step 3: Accumulate gradients over the input patterns (batch)

$$\frac{\partial E}{\partial W_{ij}} = \frac{\partial E}{\partial W_{ij}} + \partial_{2j} z_i$$

$$\frac{\partial E}{\partial W_{ri}} = \frac{\partial E}{\partial W_{ri}} + \partial_{1i} x_r$$

Step 4: After doing steps 1 to 3 for all patterns, we can now update the weights:

$$w_{ri}(new) = w_{ri}(old) - \frac{\mu}{L} \frac{\partial E}{\partial W_{ri}}$$

$$w_{ij}(new) = w_{ij}(old) - \frac{\mu}{L} \frac{\partial E}{\partial W_{ij}}$$

Backpropagation networks are necessarily multilayer perceptrons (usually with one input, one hidden, and one output layer).

Experimental Results

As FG is responsible for face perception, the images of the whole faces are considered to be the input image. The images of faces illustrated in Fig.-3 are acquired and converted into gray scale images, which in turn, transformed into binary form. Eq. 1 is used to convert RGB value of a pixel into its grayscale value.

$$gray = 0.2989 * R + 0.5870 * G + 0.1140 * B \qquad (1)$$

where R, G, B correspond to the color of the pixel, respectively. The image is converted to binary image using simple threshold technique. The whole face region is taken into account as input data. The produced binary information are fed into the backpropagation network (BPN) for learning.

Fig 3. Input Images.

In this study the algorithm of backpropagation network has been implemented employing C++. The number of face images, size, learning rate, input and output neurons have been considered as 4, 50X50 pixels, 0.5, 2500, and 2 respectively, in the present BPN. All these processes are implemented based on the basic block diagram as shown in Fig.-4.

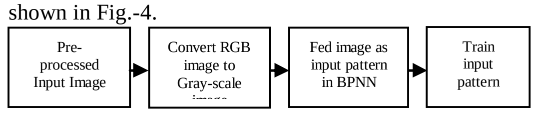


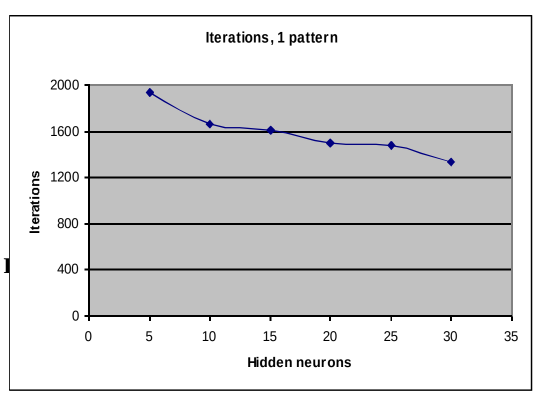
Fig 4. Block Diagram.

At the time of train the network, the hidden neurons have been varied to observe the learning pattern of the FG for different set of input images shown in Table-1. It has been observed from Fig.-5, 6, and 7 that the learning pattern improved as hidden neurons increased for different input images. When neurons in the network increased, the face processing tasks of patients with autism seems to be normal. These results also justify the observation of fMRI for the autistic patients.

Table 1. Hidden neurons vs. Iterations.

Number of Hidden Neurons	Number of Iterations (1 Pattern)	Number of Iterations (2 Patterns)	Number of Iterations (4 Patterns)
5	1939	8007	41613
10	1665	7402	25767
15	1604	6978	20074
20	1495	6800	17915
25	1471	5809	10548
30	1328	4123	6928

Fig 5. Hidden Neurons vs. Iterations (1 pattern).



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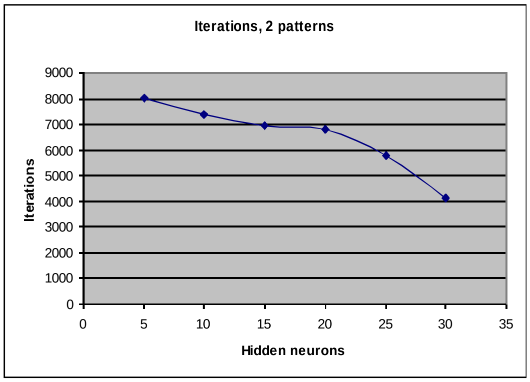
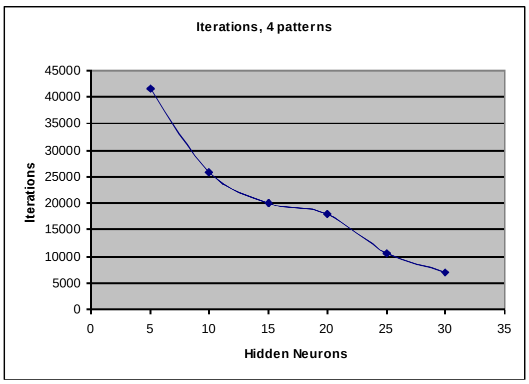


Fig 7. Hidden Neurons vs. Iterations (4 patterns)



Conclusion

Till today, there is no core mechanism that could explain the assortment of symptoms found in autism. In fact, autism is a mysterious brain disorder in which numerous abnormalities in the activity of brains prevail. New findings indicate a deficiency in the coordination and cooperation among brain regions. To explore the biological aspects of autism needs details investigations of the whole brain regions which require further in-depth studies.

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