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A Computational Model of Neuron to Analyze Biological Characteristics of Autism

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Abstract: Autism is a potential threat to the present world as 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. Autism is characterized by i) impairment verbal and non-verbal communication, ii) impairment social interaction, iii) lack of imagination, and by restricted and repetitive behavior. Newly emerging theories of neurological functioning in autism are highlighting inter-regional functional and anatomical connectivity of the brain. In the present work, a computational model of the neuron is constructed using electrophysiological and morphological data to analyze autism. The data are considered for the rat sub-thalamic neurons as various researchers indicate that rat sub-thalamic neurons are tantamount to human neurons. In pursuing the study, simulation software NEURON is used to create neurons and connected them. From the response of the simulation experiment some characteristics of autism are explored.

Keywords: Computational, Brain, Modeling, Neuron, Autism, sub-thalamic.

I. INTRODUCTION

Autism is part of a spectrum disorders characterized by a triad of symptoms including deficits in all aspects of social reciprocity, pragmatic communication deficits and language delays, and an assortment of behavioral problems, such as restricted interests, sensory sensitivities and repetitive behaviors [1]. Autism is a neurodevelopment disorder characterized by mild to severe qualitative impairment in communicative abilities and reciprocal interaction as well as repetitive and stereotyped behaviors.

Autism is commonly considered a spectrum disorder (Autism spectrum disorder, ASD), ranging from profoundly isolated, mentally retarded individuals to intellectually brilliant individuals who only behaves oddly during social interaction. The prevalence of autism seems to have dramatically increased during the last decade, and recent studies [2] report that as many as 1 in every 166 newly born children may be affected by ASD. As specific causes of autism have not yet been known and there's no medication of it. There is no apparent core mechanism that could explain the assortment of symptoms found in autism.

In the present work, a computational model of the sub-thalamic nucleus projection neuron is constructed using electrophysiological and morphological data and channel specifications and are considered for the rat sub-thalamic neurons as researchers indicate that rat sub-thalamic nucleus neurons are tantamount to human nucleus in coronal section [3]. Simulation software NEURON is used to create neurons and connect these generated neurons accordingly. Biological membrane mechanism is incorporated employing model description language [4]. From the response of the simulation experiment of this computational model one can explain some biological aspects of autism.

The remainder of the paper is organized as follows: section 2 provides the rational of the study. The research Methodologies described in section 3. Description of system model is discussed in section 4. Section 5 provides the system methods and structure. System result are discussed in section 6. System limitation are described in section 7. Finally the conclusion is drawn in section 8.

II. RATIONAL OF THE STUDY

By the research findings an effective biological aspects of autism are explored. Nowadays autism is a most threatening issue in modern life. Autism is a pervasive developmental disorder developed during early childhood. It is important to seek help for the autistic child as soon as possible, as early intervention can help solve many issues before they worsen. Many children are also able to recover from autism. If not, they may still be able to enter a mainstream school. Autism is a developmental disorder. In order to detect symptoms as early as possible, parents can pay close attention to how well their child is meeting developmental milestones [5].Through this computational model autism can find at the early stage of a new born child.

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III. METHODOLOGY

It was an experimental research in design. At first we construct a neuron using electrophysiological and morphological data and a restricted set of membrane channel specifications. Here we use two dendritic tree data sample of rat sub-thalamic nucleus projection neurons which are tantamount to human neurons and test the output result in our proposed system. We have conducted experiment of our model in laboratory environment only.

IV. SYSTEM MODEL

Here our system is developed by rat sub thalamic projection nucleus neuron which are equivalent to human nucleus in coronal section. All of these neurons have basically the same morphology, a cell body with dendritic trunks with complex branching. To model sub thalamic nucleus neuron the following procedures are shows in Fig.1.

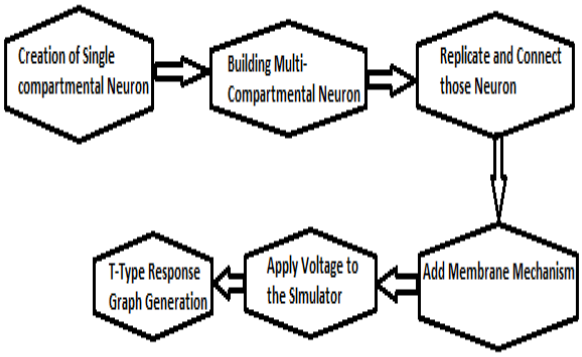

Fig.1.System Model of Simulation

V. METHODS AND SYSTEM STRUCTURE

Following procedures are followed to create more realistic neuron and generation of voltage graph [6]:

1. Create a single compartment neuron model with Hodgkin-Huxley conductance's, run the simulation and displaying the simulation results.
2. Building multi-compartmental neurons and using different types of graphs to display the results.
3. Replicate neurons using templates and connect these neurons together.
4. Add new membrane mechanisms to the simulator and incorporate them in this neurons using NMODL
5. Generation of T-type response graph.[4]

In a cell's soma (and dendrites), are represented by what are called sections. Sections in are cylindrical in nature and, for computational reasons, can be divided in to smaller areas called segments. Each sections created here has the default properties already manipulated but two other built in channel membrane mechanism: Hodgkin-Huxley channel (hh) and passive channel (pas) are explicitly inserted with their own properties.
A single compartmental neuron is created by incorporating soma, membrane channel and electrode properties to the neuron. In this program the soma is the default section so the soma voltage is plotted by default. After the simulation a voltage graph display the output voltage in the soma.
A model description language (NMODL) is incorporated to the simulation software "NEURON" for defining additional distributed membrane mechanisms such as ion channels and point processes to make the neurons much more electrophysiological characteristic of sub thalamic.

Adding more section representing the two dendrites make this single compartmental neuron to multi-compartmental. This is very important for accurate simulation and this has the effect of increasing the spatial resolution of the cable equation. This model is entirely independent of the numerical details because the reason for distinction between sections and segments allow to create models that do not rely on the number of segments in the model. Normally the electrical potentials travelling down the dendrites to the soma implying that spatial dimensions are important. Increasing the number of segments in the section are increase the spatial resolution of the dendrite. The two dendrites contain 23 and 11 sections respectively for creating a realistic model neuron. A voltage graph are plotted the voltage halfway down the default section and it is done for comparing the voltage of the soma and a distal part of a dendrite. A model description language (NMODL) is provided for defining additional distributed membrane mechanisms such as ion channels and calcium pumps and point processes such as synapses to make the neurons much more electrophysiological characteristic of sub thalamic.

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An important electrophysiological feature of sub thalamic neurons is the post hyperpolarizing response. When a neuron is hyperpolarized (e.g. by current injection or inhibitory synaptic input), at the end of the hyper polarization, a burst of activity is observed in sub thalamic projection neurons. This response is mediated by a low threshold calcium selective ion channel, called the T-type calcium channel.

A. Proposed System Model Data

The following data are used to create a soma and electrode properties of neurons**.**

TABLE 1 DATA OF SOMA PROPERTIES [4]

Nseg	**diam**	**L**	**Ra**	**gnabar_hh**	**gl_hh**	**el_hh**
1	18.8	18.8	123.0	0.25	.0001666	-60.0

TABLE 2 DATA OF ELECTRODE PROPERTIES [4]

Del	**Dur**	**amp**
100	100	0.45

VI. SYSTEM RESULTS

The following output response by the end of simulation is generated to observe various characteristics of a neuron to analyze autism.

An important electrophysiological feature of sub thalamic neurons is the post hyperpolarizing response. When a neuron is hyperpolarized (e.g. by current injection or inhibitory synaptic input), at the end of the hyper polarization, a burst of activity is observed in sub thalamic projection neurons which is shows in Fig.2. This response is mediated by a low threshold calcium selective ion channel, called the T-type calcium channel.

In three dimensions it is sometimes difficult to see the real extent of the dendritic arborization. In this case following graph shows the three dimensional view using rotation which is shown in Fig.3.

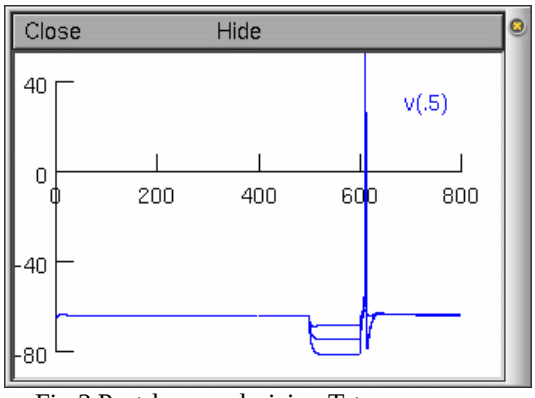

Fig.2.Post-hyperpolarizing T-type response

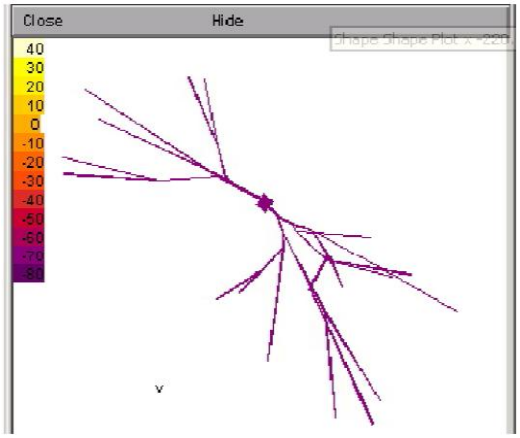

Fig.3'. Three dimensional view of the neuron

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A post-hyperpolarizing T-type response is observed by injecting a hyperpolarizing current in one of this neurons. With current injections at -0.1, -0.2, and -0.3 nA.

VII. LIMITATIONS

There are few limitation of this work. Here rat-sub thalamic nucleus projection neuron data is used to simulate and explain autism but if the real human brain data is found then the work will be more precise and accurate.

VIII. CONCULATION

Post hyperpolarizing T-type response graph is plotted by injecting current in any neuron. Various researchers indicate misses' mutations in the calcium channel in 6 of 461 individuals with ASD, which does not produce post hyperpolarizing T-type response. That means only autistic brain neuron produce the T-type response. Functional analysis shows that all these mutations significantly reduce calcium channel activity and thus could affect neuronal function and potentially brain development. 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. Thus the absence of detectable level of T-type currents in dissociated STN neurons may be attributable to loss of dendritic processes during dissociation, and suggests the possibility that STN neurons express T-type channels preferentially in dendrites. The function of the STN is unknown [7], but current theories place it as a component of the basal ganglia control system that may perform action selection. This notion, however, is based on the negative finding of T-type currents in dissociated neurons.

To explore the exact biological cause of autism, molecular investigations of the anatomical and functional connectivity of neuron are very important which need further detailed study.

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