Digitizing Human Brain

Authors
Diwijesh Prajapati¹, Ms Pooja Khanna²
¹M.Tech CSE ²Associate Professor
ASET, Amity University
Email-nishu.dev.9@gmail.com

ABSTRACT

Human brain is most complex and unique creation of nature which is developing from ages by adaptation process and making humans more and more intelligent. The objective of this research is about how we can digitize the human brain with the study of blue brain project and applying in real life scenario. This will take decades of time to digitize the human brain; my research is a small work in this field. My model of digitizing human brain based on blue brain project and taking the data of fMRI and applying on neural networks will give a way to digitize the human brain. Here my work is to get the deep knowledge of on-going blue brain project and create my model of digitizing the human brain based on fMRI and study of blue gene supercomputer, quantum leap, blue column which are part of blue brain project.

Keywords: MRI, neocortical, neurons, neural network, RTNeuron, spikes, virtual brain.

INTRODUCTION

IBM is building up world's first virtual brain. It will take decades to get at some level of making virtual brain. Blue brain undertaking is a push to recreate the human brain digitally at cell level by figuring out procedure. Blue brain task was begun in July of 2005[1], under prof. Henry Markam from Brain Mind establishment at EPFL and IBM. They expected to make a virtual brain by displaying the neocortical column. Neocortical column is discovered just in mammals. It spares the data about environment, sustenance and different assets which are essential for survival. Neocortical column underlines all tactile and data handling with higher mental capacities, general developments and behavioural reactions[3].

Figuring out a segment of neocortical column incorporates numerous levels of insights about minute cells and neuron strands in living brain and their dynamic substances. Blue brain undertaking is running on supercomputer called Blue gene[2]. Blue gene is a supercomputer created by IBM, which is included in blue brain undertaking to mimic the warm blooded creature's brain with abnormal state of exactness (organic), and to think about the strides required in natural insight. The computation speed goes past peta FLOPS range. As an ordinary human brain requires a fast of handling past peta FLOPS, the blue brain task is expanding the preparing force of their supercomputer blue gene, to achieve the human level of information handling.

Functional magnetic resonance imaging, or fMRI, is a technique for measuring brain activity. It works by distinguishing the adjustments in blood oxygenation and stream that happen in light of neural activity – when a brain region is more dynamic it devours more oxygen and to take care of this expanded demand blood stream increments to the dynamic zone. fMRI can be utilized to deliver actuation maps demonstrating which parts of the brain are included in a specific mental process.
SIGNALS
The brain is neither analogue nor digital, however works utilizing a sign processing worldview that has a few properties in a similar manner as both. Dissimilar to a digital computer, the brain does not utilize binary logic or binary addressable memory, and it doesn't perform binary math. Data in the brain is spoken to as far as factual approximations and estimations instead of accurate qualities. The brain is likewise non-deterministic and can't replay direction arrangements with mistake free accuracy. So in all these ways, the brain is unquestionably not "digital".

In the meantime, the signals sent around the brain are "either-or" states that are like binary. A neuron flames or it doesn't. These win big or bust heartbeats are the essential dialect of the brain. So in this sense, the brain is processing utilizing something like binary signals. Rather than 1s and 0s, or "on" and "off", the brain utilizes "spike" or "no spike" (alluding to the terminating of a neuron).

**Figure 1**: Different kind of signals

**Figure 2**: This recording of neural spikes over time shows that the spatiotemporal pulses of the neural code looks a lot like digital signalling.

ARTIFICIAL NEURAL NETWORKS
Neural network are the biological networks for neurons in brain, which connects each other and performs functions on different inputs.
Artificial neural networks are the digital copy of biological neural networks. Here in figure we can see the basic structure of ANN. $X_i$ is the inputs, each input has there weights which can be updated later for learning process. Input weights and input values are multiplied, with adjusting threshold value and activation function, output is generated.

$$U_j = \sum(X_i \times W_{ij}) \quad \text{Equation 1}$$

$$Y_j = F_{th}(U_j + t_j) \quad \text{Equation 2}$$

$X_i$ for each $i$ input multiplied by weight $W_{ij}$, for each neuron $j$, forms this we get $U_j$ which is an internal value. $U_j$ is added with threshold value $t_j$, which is previously defined and this addition of $U_j$ and $t_j$ is gone under Activation function $F_{th}$, which is as sigmoid function and generated output $Y_j$. This value $Y_j$ is an input for neuron in next layer and so on for performing desired output $Y$.

**BLUE BRAIN**

Blue Brain is more than an associated style reconstruction of a couple of dendrites and their nearby circle of neural connections. That is not to remove anything from the awesome anatomical reproductions of tasks like Eyewire and Jeff Lichtman's Brainbow. In spite of the fact that Markram's model catches the execution of atomic scale ion pumps and channels — proteins even beneath the point of interest we find in Lightman's symbolism — these elements get algorithmically lumped together by element equations. Additionally, the connection subtle elements in the Blue Brain model are likewise generated pretty much naturally from crude information. Generate it? For that, the group utilized patch brace terminals to record the activity of more than 14,000 individual cells in cuts of cortex.

The cells were additionally recolored with the goal that they could see the genuine shape and structure, and after that arrange them likewise into 207 novel 'morpho-electrical' cell sorts.

Be that as it may, what precisely was the underlying type of this information, and how could they have been able to them first.

Blue brain project used RTneuron for neural stimulation. RTneuron[7] is software developed by blue brain project team which is based on C++. RTNeuron takes the output from Hodgkin-Huxley simulations in NEURON and render them in 3D. This allows researchers to analyse the connections through neuron and within neuron.
Here we can see the difference in brain activity for participants who viewed the same pictures in order of food which were labelled and unlabelled.

Participants response at each picture, that they will try the food or not by tapping there finger. Foods which were familiar shows brain activity mostly in occipital lobe which is responsible for visual recognition and it is also where dreams made. On the other hand, foods which were unfamiliar shows brain activity in areas such as, occipital lobe and frontal lobe. Frontal lobe is centre were problem solving and decisions/judgments are made, analysis is done and it also deal with memory. This huge difference in brain activity shows difference in recognising familiar and unfamiliar things, matters, peoples etc., and this is also unique for every individual.

**WORKING OF MODEL**

Digitizing human brain is the most complex, futuristic and advance field of research. Blue brain project is working to generate the electrically mapped brain connections (neural network) which is obtained or is likely to be obtaining by analysing the sliced brain sections and mostly neocortical column.
Now the issue arises how these brain connections will be synchronises with individual human brain. The fMRI scans are one of the solutions of it. fMRI scans gives the live working of individual brain. fMRI scans will help in understanding the features, behaviours and functioning of an individual brain. fMRI scans of an individual can define their threshold values at each recognition and non-recognition generally.

**Network model**
Blue brain project generates neural network data of a general brain, which is done by electrically captured neuron database. These neuron databases are saved as examples and will apply on different individuals to create their virtual brain database. This will generate brain activity map for an individual. Blue brain project has an estimation of two three decades for generating human brain neural network. This project will give the network model of human brain on which nodes have weights and threshold values can be adjusted for generating desired output.

**Capturing data**
There is difference observe in brain activity where we show familiar and unfamiliar images and hearing sounds. These activities are recorded and generate an initial database which is later updated time to time. In result we get the virtual brain data of an individual.

Capturing live scans of human brain is required for digitizing human brain. Device which is able to capture human brain activity live and can sample the images and sounds what are seen and hear by that individual. This device is worn on head by individual for capturing brain activity.

fMRI scans of an individual generates their brain activity on different conditions. These activities are captured with measuring the level of colour intensity, which will define the threshold value of those area neurons.

![Figure 7: fMRI scan example](image1)

![Figure 8: colour intensity](image2)
Threshold values in equation 2 are changed by the colour intensity based on fMRI scan reports.

\[ Y_j = F_{th}(U_j + t_j) \]

Value of \( t_j \) is change for generating desired output \( Y \).

Inputs

Input for each neuron is defined by result of scan reports of an individual.

\[ U_j = \sum (X_i \cdot W_{ij}) \]

The input \( X \) is calculated by analysing the familiar and unfamiliar recognition activity in brain on range of 0-1. Weights \( W_{ij} \) is set by observing behaviour and nature of that individual. For example, different behaviour has different brain activity.

\[ \text{Figure 9: fMRI scan on different behaviour.} \]

Output

The desired output is what we see in fMRI scan reports. The output \( Y \) is output of calculated input and threshold values. This output is measured and corrected by error correction by comparing desired output and \( Y \) output.

\[ \text{Figure 10: error correction} \]

\[ W_{ij} = W'_{ij} + LR \cdot e_j \cdot X_i \quad \text{Equation 3} \]

\[ e_j = Y_j \cdot (1 - Y_j) \cdot (d_j - Y_j) \quad \text{Equation 4} \]

Weights of node \( ij \) is adjusted in Equation 3, where \( LR \) is learning rate, \( e_j \) is error calculated in Equation 4. \( e_j \) is calculated by comparing desired output ‘\( dj \)’ to generated output \( Y \).

While the data capturing is going on, the head gear which records the live brain activity is also contains camera and microphones, which records the scan data with what type of vision and sound is an individual is seeing and hearing during capturing process and this data is work as training data.

There are image recognition ad sound recognition tools which are being used here for capturing and comparing image and sound data.
My model of digitizing human brain has not any working tool or technology, it is a proposed model for how we can digitize the human brain in next one or two decades, based on Blue brain project and fMRI scan technology.

CONCLUSION

We can develop digital brain; it’s just matter of time, how sooner it’s going to happen. Right now we are lacking in technology as like in computing power, algorithms, logics over all we can say we are missing Quantum computing. Blue brain project has done a futuristic work with limited technology. My model of
Digitizing human which is based on Blue brain project and fMRI ‘is an’ future happening thing. But, it will happen.

**FUTURE SCOPE/LIMITATIONS**

My model of Digitizing human brain has a futuristic view. Sure this blue brain project is going to take time, but at result, with applying other tools, we are getting a digital human. Many universities have their separate labs dedicated to Artificial intelligence. This idea of digitizing human brain will come in true within next two or three decades. More and more research and work is required for increasing the level of computing power and technology in the direction of Digital human.

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