Engineering Rewiring of the Body to Treat the Motor Neurone Disease

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Abstract: - In this paper a comprehensive treatment of *Motor Neurone Disease* is proposed. To achieve this goal a *Neurone Impulse Generator* is built. The action impulses produced by the *Neurone impulse Generators* are used to inject the dendrites of the motor neurons by the right number of impulses per second. The idea is to monitor the number of action impulses per second which are produced by different motor neurons inside the body. It can be done if we connected electrodes inside the body to monitor the number of action impulses produced by the axels of the motor neurons. Then we would feed these numbers into the input ports of multiple parallel microprocessors. The microprocessors analyse the information fed to the input ports and decide whether it sends start pulses to the different *Neurone Impulse Generators* built inside the body in the *Ganglion area*. As a result, the *Neurone Impulse Generators* would produce the right number of impulses needed by the motor neurons to function properly. Once the right number of impulses are produced by the *Neurone Impulse Generators* stop pulses are produced by the microprocessors. These stop pulses would be sent to the *Neurone Impulse Generators* via the output ports. Usually two pulses are sent to every *Neurone Impulse Generator* to stop. The outputs of the *Neurone Impulse Generators* are fed to the dendrites of the motor neurons. The triggering of motor neurons by the right number of impulses may increase its life span and limit the destructive effects of the *Motor Neurone Disease* on the internal and external muscles of the body. Comparing the work in this paper to the latest research in the area of treatment of *Motor Neurone Disease*, it is clear that this paper provides the most comprehensive treatment of the *Motor Neurone Disease.* Also, the treatment method in this paper is compatible with the other research results. In other words, the treatment proposed by the latest research work may enhance the treatment proposed by this paper and there are no contradictions between them. The details of the comparison between the research in this paper and the research of other research Institutes are mentioned in the Conclusion of this paper.

Key-Words: - Motor Neurone Disease, Neurone Impulse Generator, Ganglion area.

1 Introduction

The problem of Motor Neurone Disease is that the doctors know its symptoms and how it progresses but they don't know how to treat it effectively. Maybe if we tried the approach mentioned above, we may come up with better results.

Dr Stephen Hawking was infected by Motor Neurone Disease at age 21 and only because of the great care he receives he lived until age 76. Most of the patients of this disease die after three years of the infection due to the destruction of Motor Neurons which adversely affect the external and internal muscles. Eventually the decay of internal muscles, especially the ones which affect breathing, would lead to the death during sleeping!

We would cover some basic medical information which is necessary to understand this paper. This includes the neuron cells, types of Neuron cells, how the neuron produces action impulses, the differences between motor neuron, sensory neuron and multipolar interneurons, how neurons are connected together and the shape of its output impulses.

Also, we cover how sensory neurons communicate with motor neurons, how motor neurons work and how they are connected to the muscles.

Once we cover this material, we would be able to understand the design and the construction of Neurone Impulse Generator. The Neurone Impulse Generator is the basic building block in the proposed treatment of Motor neurone Disease.

2 Symptoms of the Disease [1]

I would use the NHS symptoms document as my source of information in this part [1].

The symptoms usually follow a pattern that falls into three stages:

- The initial stage
- The advanced stage
- The end stage

Read more details in the NHS document reference [1].

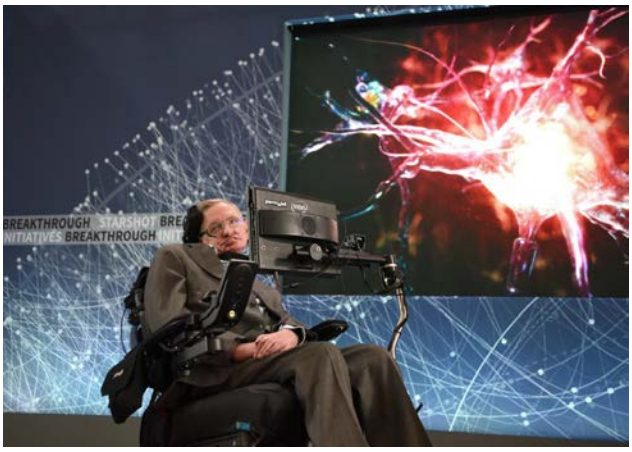

Fig.1: Dr Stephen Hawking was infected by Motor Neurone Disease at age 21.

3 The Types of Neurons and How They are Connected Together

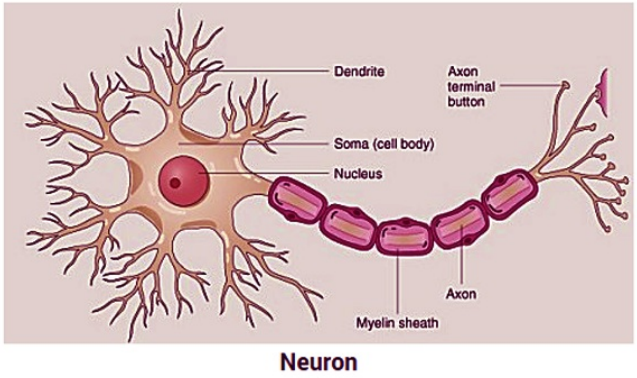

Fig.2: What is a Neuron?

Fig. 2 shows the construction of a Neuron. It is the basic building block of the nervous system. It has a main body called the Soma, it has a Nucleus inside. The axon stems out of the Soma. The axon produces action impulses if it is triggered. The axon can be connected to other Neurons through the axon's Synapses which are connected to the Dendrites of other neurons [2]. The axon has nodes of Ranvier every 2 μm and is covered by insulating layer of Myelin sheath. The axon has branches end by terminal buttons or synapses. These synapses transfer the action impulses to other Neuron cells via its dendrites. Later we will see in details of how two Neurons are connected together.

3.1 Here is another picture of a Neuron which has more details if you are interested to know more about it

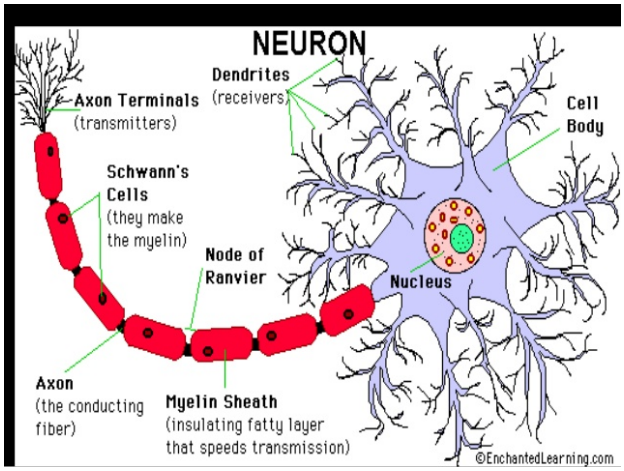

Fig.3: More details about the construction of a Neuron.

3.2 There are Three Types of Neurons [3] as shown in Fig. 4

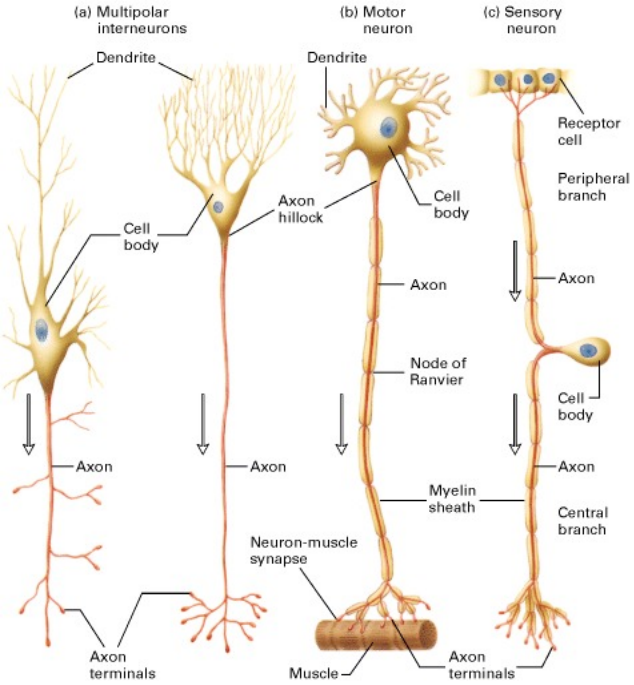

Fig.4: The different types of Neurons

3.3 These Types are

- Multipolar Interneurons
- Motor Neurons
- Sensory Neurons

When the sensory Neurons detects any signal, it connects it to the Motor Neurons via the Interneurons. In other words, the Interneurons are the connection between the sensory Neurons and the Motor Neurons. The Motor Neurons are connected to the internal and the external muscles of the human body.

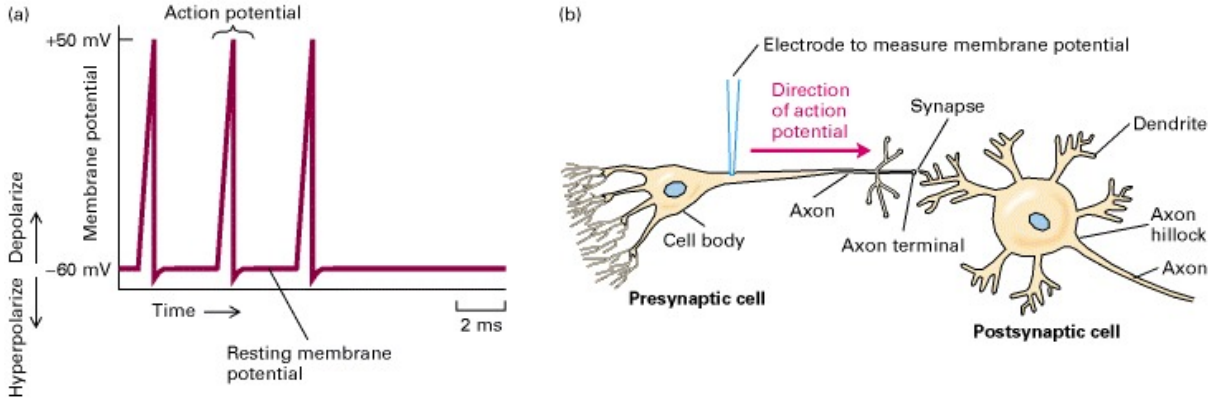

Fig. 5(a): shows the Action Impulses.
Fig. 5(b): shows a connection between two Neurons.

The resting membrane potential is -60 mV. When action happens, depolarization would change the potential inside the neuron from -60 mV to +50 mV then hyperpolarization will reduce the potential to -90 mV then it goes back to its resting potential -60 mV. The speed of these impulses is 100 Meters/sec. The time between two impulses is 4 m Sec.

In Fig. 5(b) there are two Neurons connected together. The Left-Hand Side one is called Pre-synaptic cell and the Right-Hand Side one is called the Post-synaptic cell. If the Pre-synaptic cell is stimulated action impulses are generated at the Axon hillock. Note the electrode in Fig. 5(b) which measures the impulses travelling down the Axon of the Pre-synaptic cell. The Axon of the Pre-synaptic cell is connected to the dendrites of the Post-synaptic cell via the synapses of the Pre-synaptic cell. In other words, the dendrites are the receptors and the synapses are the transmitters. The impulses cause the synapses to release the neurotransmitters that bind to receptors in the postsynaptic cell, generally depolarizing the membrane and create the impulses in the Post-synaptic cell.

The action impulses cause the Motor Neurons to move the muscles. Without these impulses, the muscles will decay and the body will slowly die as we will see when we cover the details of the **Motor Neuron disease**. The arrows in the above figure shows you the direction of travel of the action impulses.

Fig. 5 shows the connection between two Neurons and it shows also the action impulses which are transferred between the Neurons [3].

4 Motor Neurone Disease

Motor Neurone disease causes the destruction of motor neurons such as the muscles which control speaking, swallowing and breathing. As a result, the patient dies. Motor neurons are in the Cerebral cortex of the brain or the stem of the brain. Other Motor neurons are in the Spinal cord. Fig. (6) shows a human brain where you can locate the Motor neurons in the brain [5].

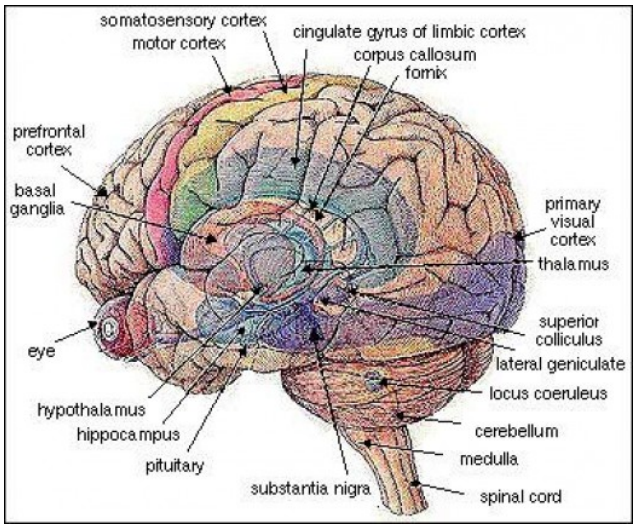

Fig. 6: The brain of a human, you can find the Motor neuros in the Motor Cortex, Cerebellum and the spinal cord.

The cerebellum is the area of the hindbrain that controls motor movement coordination, balance, equilibrium and muscle tone. Here there are more pictures of Cerebellum [5]:

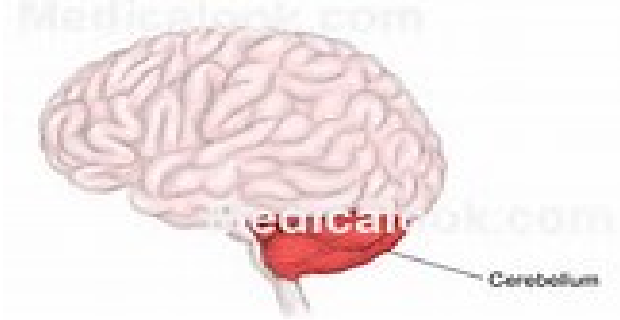

Fig. 7: The Fig shows another picture of the Cerebellum, it is the Red (darker) part in the figure.

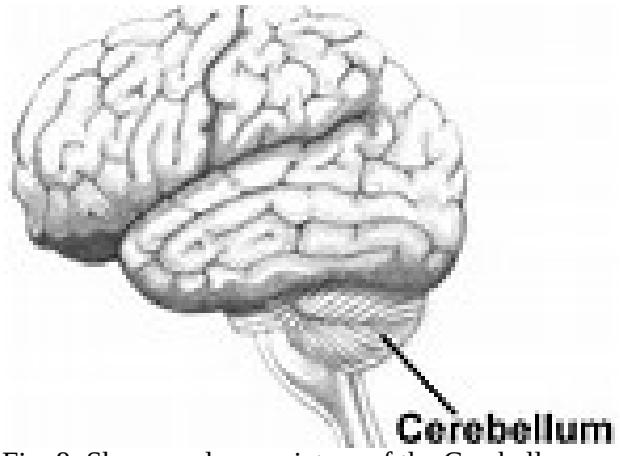

Fig. 8: Shows a clearer picture of the Cerebellum.

The primary motor cortex is a brain region that in humans is located in the dorsal portion of the frontal lobe. It is the primary region of the motor system and works in association with other motor areas including premotor cortex, the supplementary motor area, posterior parietal cortex, and several subcortical brain regions, to plan and execute movements [6].

Here is another picture of Motor Cortex;

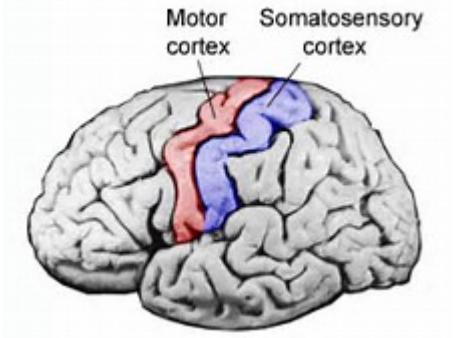

Fig. 9: It shows the Primary Motor Cortex (The Red or dark Part) [6].

In the Motor Neurone especially the ones located in the spinal cord [4] their axons stick out to reach the muscle fibers as shown in Fig.10.

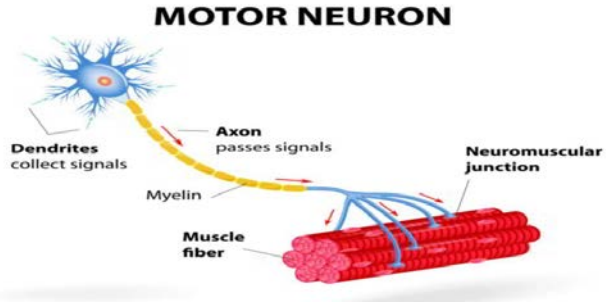

Fig. 10: Motor Neurone connected to the muscle fibbers through its axon. The Motor Neurone is multi-polar which means that it has many dendrites to detect the weakest signal then move the muscle in the right direction.

The functions of the Motor Neurons [4] classify them into three types, somatic motor neurons, general visceral motor neurons, and special visceral motor neurons.

The somatic neurons are connected to the skeletal muscles, which are responsible for movement. Some skeletal muscles include intercostal muscles, thigh and limb muscles, arm muscles, and several others which help in the movement of bones and support the skeleton.

Visceral neurons are specifically designed to stimulate organ-related muscles. The special visceral neurons control the branchiomeric muscles. Branchiomeric muscles are basically muscles of the face and neck. The general visceral neurons stimulate cardiac muscles, smooth visceral muscles, and also certain gland cells.

4.1 How Sensory Neurons Communicate with Motor Neurons?

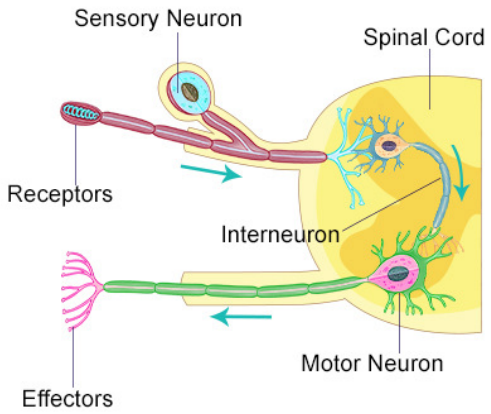

Fig. 11: When Sensory Neuron is stimulated it tries to transfer this stimulation into the Motor Neuron

which is located in the Spinal Cord. The Motor Neuron's axon stretches out to reach the muscles to be able to control them.

The Sensory Neurons are connected to the Motor Neurons via a group of Interneuron cells. As shown in the above figure there is one Interneuron cell connecting the Sensory Neurone to the Motor Neurone. If the Motor Neurone doesn't know what to do exactly then it communicates with the Motor Neuron cells in the brain as shown in figures 7, 8 and 9.

4.2 Reflexes

Here the motor neuron acts independently.

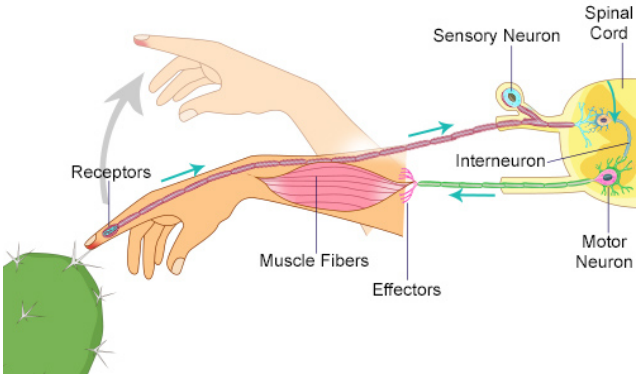

Fig. 12: It is clear from this figure if the body sensed a harmful event the Sensory Neurone transfers the danger into the Motor Neurone via the Interneurons. As a result, the Motor Neurone would pull the muscle to keep the finger away from the thorns.

In this case, the Motor Neurone in the Spinal cord doesn't need to communicate with the upper Motor Neurons in the brain. Usually this happens if there is a need to think and a decision is needed.

From the above covering, no one can survive without Motor Neurons. That is why we suggest rewiring the body such that we keep the Motor Neurons in good shape and keep monitoring them. If they are destructed then we may need to transplant them. Combining the microprocessors system, Neuron Impulse generators and monitoring the activities of the Motor Neurons may put us on the beginning of the road to find an effective treatment to the Motor Neurone Disease. In the coming pages, we would try to implement these ideas in a clearer way.

5 Engineering Re-wiring of the Human Body

5.1 Neurone Impulse Generator (NIG): Its block diagram is shown in next figure (Fig. 13).

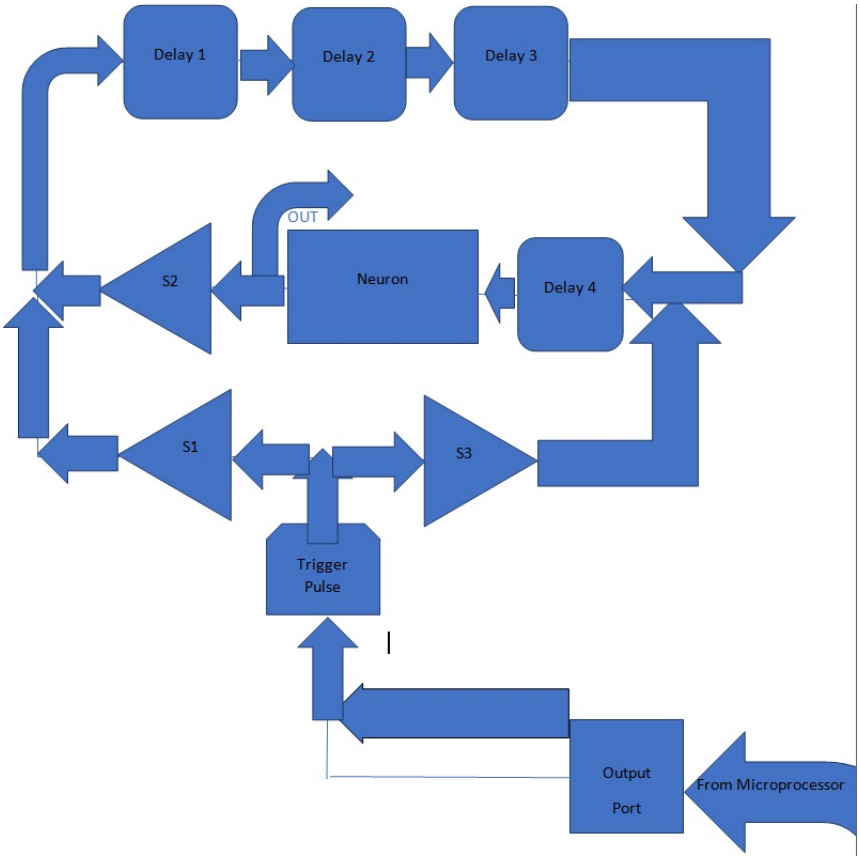

Fig. 13: NIG

The idea of this Neurone Impulse Generator is to create self-feedback loop in a Neurone by connecting the synapses of its axle to the cell's dendrites. In theory, we would be able to create a train of impulses for specific period of time then we can restart it again when we need. This idea is critical in the self-wiring technique which was introduced in this research. First, we should know the number of impulses/Sec needed for a specific healthy Motor Neurone cell to function properly. Second, if we measured the actual number produced by a Motor Neurone cell and it was less than the required number for the Neurone cell to function properly then we can feed its dendrites the missing number of the impulses needed for the Neurone to function properly. In other words, we can start operating this loop when we need and stop it when we need as I will explain later. It is possible, if we continued feeding the Motor Neurone cells the right number of impulses then it may live longer and certainly the skeleton muscles and the internal muscles will not decay.

Note that when we measure the number of impulses produced by a Motor Neurone cell we use an electrode then we feed this number to an input port. The microprocessor would examine this number and decide whether extra impulses are needed. If this is the case then it will produce starting pulse via its output port which will trigger excitatory synapse S1 to start the loop. When the microprocessor needs to stop the impulses, it sends one or two pulses to the inhibitory synapse S3.

This is the basic idea in rewiring the body. We need to keep the Motor Neurone cells and the human muscles attached to them in good shape as long as possible. On the negative side, the Motor Neurone cells may still die after a while then transplanting them would be an option. If the technology to transplant them is not possible now it may become possible in the future. Also, we may be able to put them, outside the brain or the spinal cord, in the Ganglion area!

A similar circuit was introduced by J. R. Burger [2] and he simulated them successfully [7-10]. Looking at the operation of my circuit we find that it starts when the output port receives starting pulse from the microprocessor to start the loop through Synapse S1. Synapse S3 wouldn't be able to stop the initiation of the loop because it's negative output wouldn't change the negative resting state. In fact, for S3 to stop the train of pulses it may need two stop pulses not one. The Synapse S2 is excitatory one which is used to close the loop. The delay blocks number one to number four are used to adjust the timing between the impulses. We can adjust the timing by selecting the length of the dendrites. I think that the best type of neurons which can be used here are the Interneurons.

The main advantages of this circuit are that it is not strange device built in the Ganglion area of the body and the impulses produced by the loop are very similar to the ones produced by the neurons in the body. In other words, there is a big possibility that the body would not reject them and the action impulses produced by the Neurone Impulse Generator would be very similar to the ones produced by the neurons in the body.

5.2 Creating a Parallel Artificial Centre Nervous System: Here is the CNS block diagram.

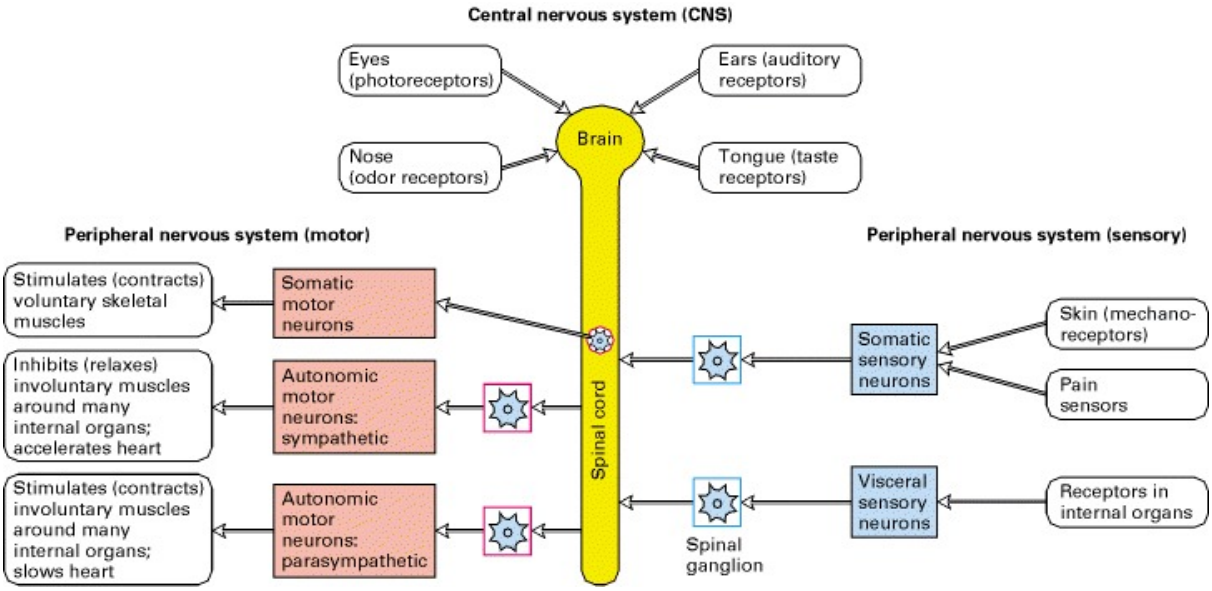

Fig. 14: The Central Nervous System (CNS) in Humans [3].

Fig. 14 shows a human Nervous System. The brain has its sensors in four areas, auditory receptors by the ears, taste receptors by the tongue, photo receptors by the eyes and odor receptors by the nose.

The body has Somatic Sensory Neurons which detect any pain or burning affecting the skin or the external body in general. The Somatic Sensory neurons are located in the spinal ganglion outside the spinal cord. They are known as the Peripheral Nervous System (PNS).

Also, there is another type of sensory neurons called the Visceral Sensory Neurons. They are located also in the PNS area outside the spinal cord. They relay information to the CNS via receptors in the internal organs.

Fortunately, the Sensory Neuros don't get destroyed like the Motor Neurons. Nevertheless, we can transplant sensors if needed. The somatic Motor Neurons are inside the spinal cord. They stimulate the voluntary skeletal muscles [3]. The Sympathetic Autonomic Motor Neuros are located outside the spinal cord in the Ganglion area. They relax the involuntary muscles around many internal organs and accelerate heart [3].

The Parasympathetic Autonomic Motor Neurons are located also outside the spinal cord in the Ganglion area. They contract many involuntary muscles around many internal muscles and slow heart [3].

5.3 So, what about our parallel artificial CNS-System?

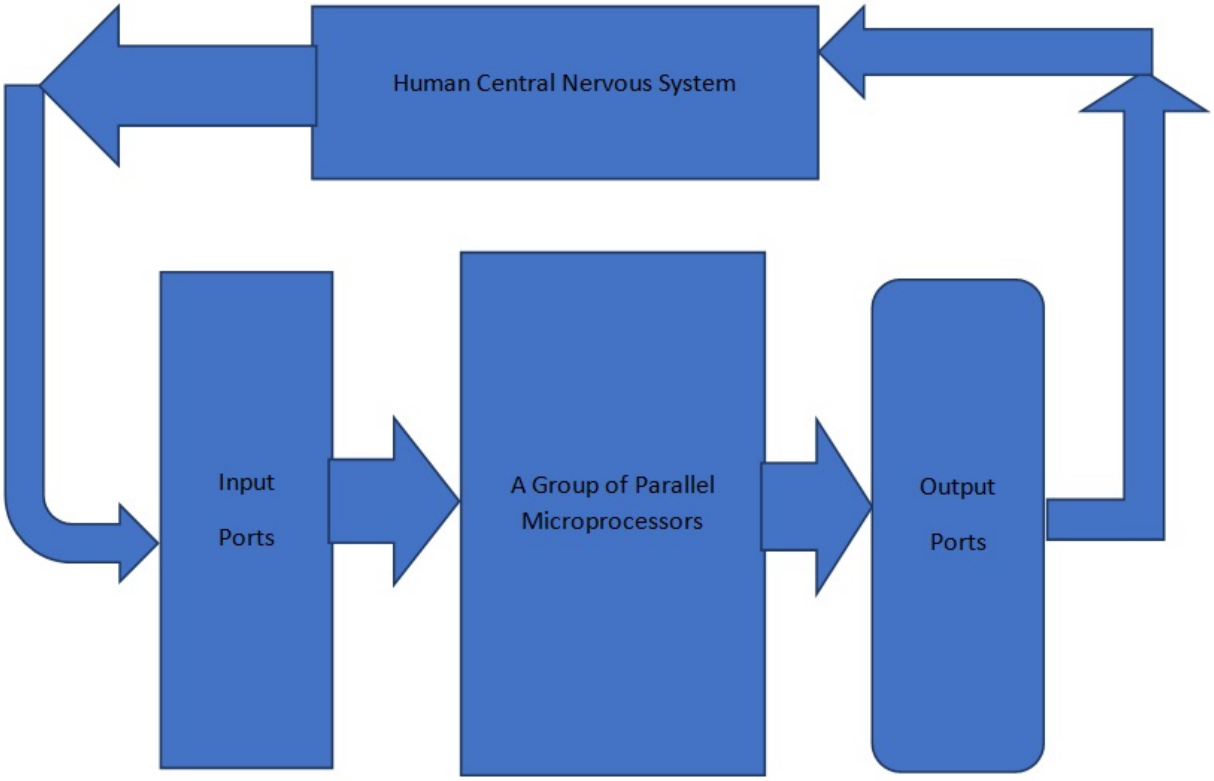

Fig. 15: Alternative Artificial Central Nervous System

5.4 The Parallel Artificial CNS System

5.4.1 Stage 1: When the patient knows that he has Motor Neurone Disease

First all the Autonomic Motor Neurons in the Ganglion area have to be monitored by fixing electrodes to measure the number of active impulses produced by the Motor Neuron cells. The number of active impulses produced by the Motor Neurons are fed into the input ports as shown in Fig. (15). Also, the Neurone Impulse generators have to be built in the Ganglion area. The Microprocessors should monitor closely the internal organs and adjust the number of impulses coming out of the Motor Neuron cells. Once the microprocessor knows how many impulses are needed to be produced by the Motor Neuron cells it feeds this data to the output port. The output port feeds the start pulse to the Neurone Impulse Generator to start producing the train of impulses then the microprocessor feeds another stop pulse via the output port to terminate the train of impulses. These impulses would be fed to the dendrites of the decayed Autonomic Motor Neurons.

This technique would force the decayed Motor Neurons to produce the required number of impulses to keep the internal muscles healthy. This type of operation should be repeated with every Motor Neuron to be sure that they produce the right number of impulses. This may increase the span of life of the Autonomic Motor Neurons and limit the destructive effect of Motor Neurone Disease on the Motor Neurons and the internal muscles.

For the Somatic Motor Neuron cells inside the spinal cord, we have to try to measure the impulses coming out of them. In fact, it is not difficult because their axons stretch out of the spinal cord to reach the skeletal muscles. We have to construct Neuron Impulse Generators to feed impulses to the dendrites of these Somatic Motor Neuron cells inside the spinal cord.

If this is NOT possible then we have to transplant new Motor Neuron cells in the Ganglion area. Regarding the role of input ports, the microprocessors and the output ports, it is exactly the same like the upper paragraph.

The only problem which may face the surgeon is to get access to the dendrites of the Somatic Motor Neurons inside the spinal cord. Nevertheless, every effort should be made to connect the dendrites of these Somatic Motor Neurons inside the spinal cord to the outputs of the Neurone Impulse Generators.

5.4.2 Stage 2: If the patient already lost most of his voluntary and involuntary muscles

In this case we have to try to concentrate on the vital internal muscles like the heart, breathing muscles, swallowing muscles and the muscles around the organs. We use the same technique we used above. Nevertheless, we have to realise that the purpose of stage one is to avoid completely stage 2. Luckily, the internal muscles are controlled by Autonomic Motor Neurons which are located in the Ganglion area, outside the spinal cord. This is why it will be easy to connect the dendrites of the Autonomic Motor Neurons to the outputs of the Neurone Impulse Generators. Also, monitoring the number of impulses produced by the Autonomic Motor Neurons would be easy for the same reason we mentioned above, that they are located in the Ganglion area.

6 Conclusion

We would like before concluding the research paper to discuss a real example like the one shown in Fig. 16. In this diagram we have Knee muscles, the Sensory Neuron and the Somatic Motor Neurons connected to the skeletal muscles that control the knee.

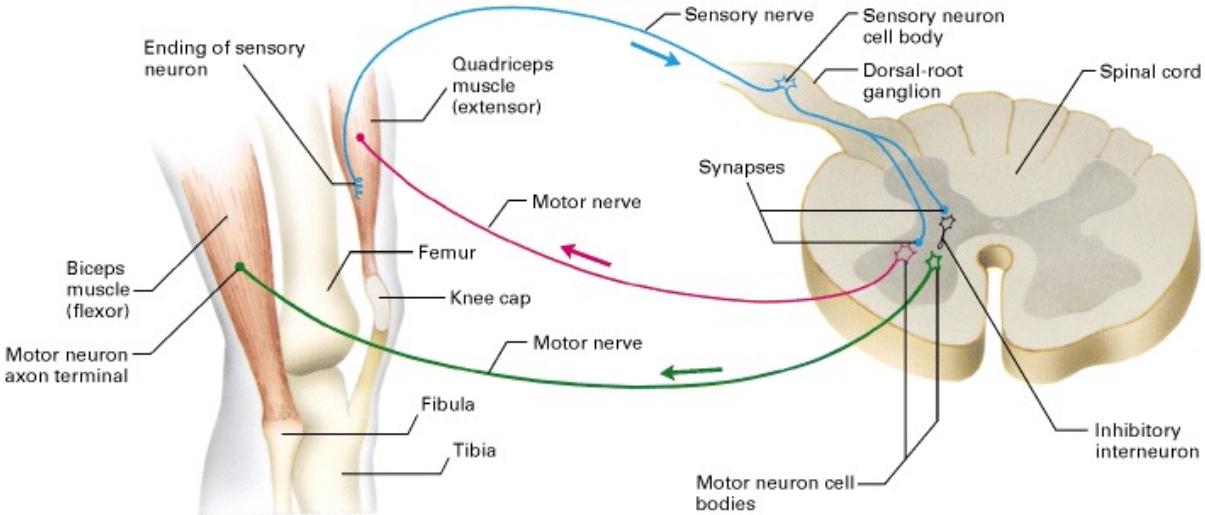

Fig. 16: The Knee-Jerk Reflex Arc in Humans [3].

In Fig. 16, Sensory Neuron is located in the Ganglion area and its axon is connected to the Quadriceps muscle from one side and from the other side its axons are connected to two Somatic Motor Neurons inside the spinal cord as we said before. One Motor Neurone is connected to the Quadriceps muscle and the other Motor Neurone is connected to the Biceps muscle.

Our first observation is that the Ganglion area can be used to construct Neurone Impulse Generators and even transplant Motor Neurons in the Ganglion area if needed. The second observation, we stated before that we need to monitor the number of impulses produced by Motor Neurons. This task is quite easy because their axons stretch out of the spinal cord. So, we can put an electrode on each axon and monitor the number of impulses then feed this data to the input ports of the Artificial CNS System (see Fig. 15). Consequently, the microprocessors would look at these numbers of impulses to know whether the Somatic Motor Neurons need to produce more impulses. If this is the case, then the microprocessors would send start pulse to the output ports. This pulse would start the Neurone Impulse Generators then once the required number of impulses are generated a stop pulse would be sent by the microprocessors via the output ports to the input of the Neurone Impulse Generators. The output of the Neurone Impulse Generators should be connected to the dendrites of the Somatic Motor Neurons. Only the Somatic Motor Neurons are the problem because their dendrites are inside the spinal cord so it needs skill from the surgeon to make the connection between the output of the Neurone Impulse Generator and the dendrites of the Somatic Motor Neurons. As we said before, the Somatic Motor Neurons are connected to the skeletal muscles and they are located inside the spinal cord. But the Autonomic Motor Neurons which are responsible about the internal organs are easily accessible because they are located in the Ganglion area. As a result, we can easily connect the outputs of the Neurone Impulse Generators to the dendrites of the Autonomic Motor Neurons. In Fig. 16, we don't have Autonomic Motor Neurone cells. We have only two Somatic Motor Neurons inside the spinal cord.

We believe if we continued on one hand to feed the Motor Neurons by impulses to force them to produce the required number of impulses and on the other hand if we fed the output impulses of the Motor Neurons to the internal and external muscles then they wouldn't decay and the effect of Motor Neurone Disease would be limited and controlled. As long as we intervene early by rewiring the body in the way We explained and construct the Artificial Central Nervous System (see Fig. 15) which will help the body to resist the decay caused by the Motor Neurone Disease.

Before concluding this paper, we need to compare it with the recent research about the Motor Neurone Disease. The first research here is a medical report from the University of Queensland in Australia [11].

The researchers have contributed to the discovery of three new genes which increase the risk of Motor Neurone Disease. They expect to discover more genes associated with mind.

This research enhances the proposed treatment in this paper because we can watch these people who got the genes and start the treatment once the early signs of the Motor Neurone Disease appear.

Another medical report published by Francis Crick Institute [12] in London. The research was about why motor neurons die in patients with Motor Neurone Disease.

A group of clinical neurologists, molecular biologists and computer scientists have worked together. They found that a protein called SFPQ which normally resides inside the cell nucleus actually leaves the nucleus in Diseased motor neurons. Again, if the scientists found a way to return the protein back to the nucleus or succeeded to stop it from leaving the nucleus then maybe we may cure the disease! Until then we keep feeding the dendrites of the diseased neurons by impulses from the Neurone Impulse Generators.

In other words, there is no contradiction between the research in Francis Crick Institute and the proposed method in this paper

The proposed method can also play a role in the treatment of the paralyzed people from the waist down.

The US-research teams at the University of Louisville and the Mayo clinic report the success of enabling three patients, all paralyzed from the waist down to walk again [13].

The scientists fit electrical patch to their spinal cord. This patch helps to simulate the lost signal from the brain to reach the leg muscles. The proposed

method in this paper can be used to simulate this signal which was lost from the brain.

We hope that the proposed methods in this paper would open the door to implement it to treat the Motor Neurone Disease and maybe it can also be implemented to treat the paralyzed people.

Acknowledgement:
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