Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(6), 1254-1261 | ISSN:2251-6727

Potential Application of Neuron with Multi Dendrites in Medicines

[1] Kaouther Selmi, [2] Mohamed Bouallegue, [3] Kais Bouallegue
[1] FSM, Electronics and Microelectronics Laboratory, University of Monastir-Tunisia
[2, 3] ISSATs, University of Sousse -Tunisia

(Received: 07 October 2023 Revised: 12 November Accepted: 06 December)

KEYWORDS
Hopfield's neural network, track of neuron, bounded region, signature of neuron, position of dendrite, EEG, ECG.

ABSTRACT:
A neural networks based on neurons with multi dendrites employing activation function with variable structure is introduced. No prior work, however, has discovered the impact of dendrites position on heavies' information to propagate. Given the frequent observations of correlations in the dendrites structure, and the importance of the spike propagation and burst problems, this is a significant gap in our knowledge. To fill that gap, we consider a model neuron with multi dendrites. In this paper, we discover that Hopfield's type of neural network can generate multi dynamic behaviors. Our contribution in this paper is to modify Hopfield's neural network in paper [5] by changing position sign of differential system equation in line two and we add a parameter of P, which has an interesting effect on the output response, we obtain four-differential system equation, which means obtaining four models of neurons. Maybe, the results reached in this work shed some light on Henry Poincare's conjuncture. Each neuron has its dynamic behavior which has never been reported before; one of them has a great similarity with real biological neuron signal. Then we notice that the dynamic behavioral response contains impact of neuron such as, signals of neurons with different directions, bounded regions with different segments and separation regions. Finally, the numerical examples will illustrate the effectiveness of this work.

1. Introduction

The central question addressed in this letter is: Given two different sets of neurons with or without activity of potential, how can they, coupled and synchronized are guaranteed to drive and to produce stable synchronous? There are few rigorous results that address this question. In most cases, rigorous results are obtained using Lyapunov functions [10-13]. Unfortunately, this method is not regular since, in practice, it can be applied only to examples. Another rigorous approach is that of Ashwin et al. [14]. To apply this approach, one must show that all normal Lyapunov exponents are negative for all measures of the dynamics. For typical dynamical systems this leads to an intensive numerical analysis. A third rigorous approach, by Walker and Mees, uses the method of Lyapunov [15]. Much effort has been devoted to understanding the relationship between Ion channels and position of dendrites First, there have been proposed methods to describe the geometry of complex neurons by Abbott et al. (1991). Using path-integral techniques, they constructed the membrane potential response function (Green's function) of a dendritic tree described by a linear cable equation. Second compartmental approach was proposed to explain the effects of dendritic structure on somatic membrane potential reset following the generation of an action potential. The majority of so-called integrate-and-fire models unrealistically assume either that the whole neuron resets on firing (e.g., Keener et al., 1981) or that the dendritic membrane potentials evolve without any influence from the nerve impulse generation process (Rospars & Lansky, 1993). No prior work, however, has discovered the impact of dendrites position on harvested.

Information to propagate. They come in an extraordinary variety of shapes and sizes, are present in all species with a nervous system and continue to develop after birth in concert with the establishment of neuronal circuitry. Generating and maintaining these elaborate structures, which occupy a large proportion of our brains Historically, the structural role of dendrites in the formation and segregation of synaptic connections has been emphasized, but their role in defining the relationship between synaptic input and neuronal output is receiving increasing attention. This convergence of different approaches should help us tease out the secrets

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(6), 1254-1261 | ISSN:2251-6727

of dendritic computation from these remarkable structures.

2. Different Neurons in Our Brain

A. Retinal bipolar cell:

Bipolar cells are one of the main retinal interneurons and provide the main pathways from photoreceptors to ganglion cells, i.e. the shortest and most direct pathways between the input and output of visual signals in the retina.

Figure 1 (b) shows an artificial neuron with one dendrite.

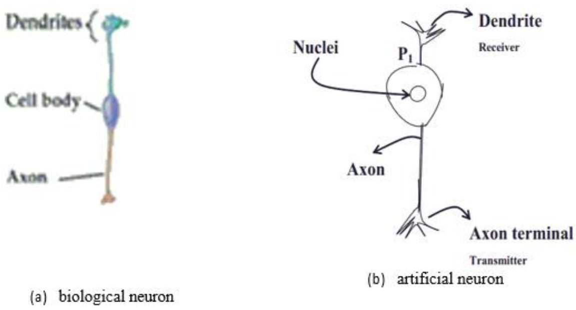


Figure 1: Neuron with 1 dendrite

B. Retinal amacrine cell:

Amacrine cells are the intrinsic interneurons of the inner retina representing the most diverse class of neurons in the retina. Generally, they receive synaptic input from bipolar cells and other amacrines, and in turn provide input to amacrine and ganglion cells as well as feedback to bipolar cells.

Figure 2 (b) shows an artificial neuron with three dendrites.

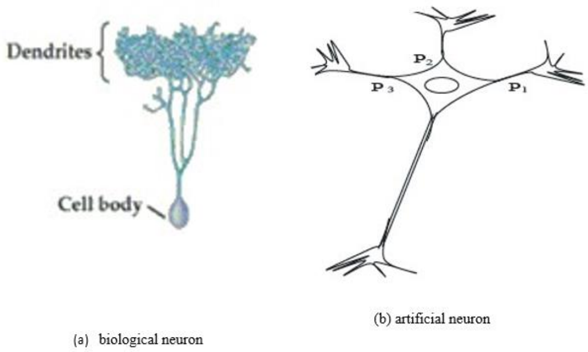


Figure 2: Neuron with 3 dendrites

C. Cerebellar Purkinje cells:

Purkinje cells are a unique type of neuron-specific to the cerebellar cortex. They are remarkable (and instantly recognizable) for their massive, intricately branched, flat dendritic trees, giving them the ability to integrate large amounts of information and learn by remodeling their dendrites.

Figure 3 (b) shows an artificial neuron with multi dendrites.

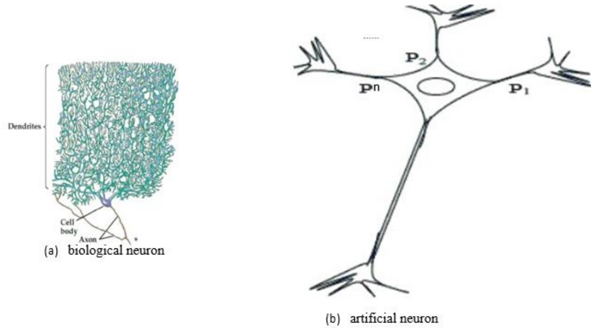


Figure 3: Neuron with muti dendrites

3. Model of Neuron with Multi Dendrites

In this section, we present some properties of dendritic. The geometry of the dendritic tree ensures that different branches can function almost independently of one another.

A. Neuron with two dendrites

In this section, we present a model (VSMN) of neuron with two dendrites using the model inspired from Bouallegue neural networks paper [15]. We give the activation function of neuron with two dendrites and its model.

$$f(x) = (x + p_1)^{n_1}(x + p_2)^{n_2}e^{-\sigma/2(x+q_1)^2(x+q_2)^2}$$

$$f'(x) = u'(x)v(x) + u(x)v'(x)$$

$$u(x) = (x + p_1)^{n_1}(x + p_2)^{n_2}$$

$$v(x) = e^{-\sigma/2(x+q_1)^2(x+q_2)^2}$$

$$v(x) = e^{-w}$$

$$v'^{(x)} = -w'e^{-w}$$

$$f'(x) = u'(x)v(x) - u(x)\, w'(x)v(x)$$

$$f'(x) = [u'(x) - u(x)\, w'(x)v(x)$$

$$f'(x) = 0 \qquad [u(x) - u(x)\, w'(x)] = 0$$

$$(x + p_1)^{n_1-1}(x + p_2)^{n_2-1}$$

$$[(n_1 + n_2)\text{x} + n_1p_2 + n_2p_1]\text{-}(x + p_1)^{n_1}(x + p_2)^{n_2}\sigma(x + q_1)(x + q_2)[2x + q_2 + q_1]\text{=}0$$

$$(x + p_1)^{n_1-1}(x + p_2)^{n_2-1}[(n_1 + n_2)\text{x} + n_1p_2 + n_2p_1\text{-}\sigma(x + p_1)^2(x + p_2)^2[2x + q_2 + q_1]\text{=}0$$

$$(x + p_1)^{n_1-1}(x + p_2)^{n_2-1}[-\sigma(x + p_1)^2(x + p_2)^2(2x + q_2 + q_1) + (n_1 + n_2)\text{x} + n_1p_2 + n_2p_1]\text{=}0$$

$$[-\sigma(x + p_1)^2(x + p_2)^2(2x + q_2 + q_1) + (n_1 + n_2)\text{x} + n_1p_2 + n_2p_1]\text{=}0$$

$$[\text{-}\sigma(x^2 + 2p_1x + p_1^2)(x^2 + 2p_2x + p_2^2) \qquad (2x + q_2 + q_1) + (n_1 + n_2)x + n_1p_2 + n_2p_1]\text{=}0$$

$$[-\sigma(x^4+2(p_1+p_2)\ x^3+(p_2^2+4p_1p_2+p_1^2)\ x^2+2(p_1p_2^2+p_2p_1^2)x+p_2^2p_1^2](2x+q_2+q_1)+(n_1+n_2)x+n_1p_2+n_2p_1=0$$

$$2x^5+[4(p_1+p_2)+(\ q_2+q_1)]x^4+2[2p_1p_2+(p_1+p_2)^2+(p_1+p_2)(q_1+q_2)]x^3+4p_1p_2+(p_1+p_2)^2+(2p_1p_2+(p_1+p_2)^2)+(\ q_2+q_1)]x^2+2(p_1p_2)+\ (p_1+p_2)+(\ q_1+q_2)]2(p_1p_2)^2-\frac{n_1+n_2}{\sigma}]x+(p_1p_2)^2+\ (\ q_1+q_2)-\frac{n_1p_2+n_2p_1}{\sigma}=0$$

$$u'(x)=n_1(x+p_1)^{n_1-1}(x+p_2)^{n_2}+n_2(x+p_2)^{n_2-1}(x+p_1)^{n_1}$$

$$u'(x)=n_1(x+p_2)^{n_2}+n_2(x+p_2)^{n_2-1}(x+p_1)^{n_1}$$

$$u'(x)=(x+p_1)^{n_1-1}(x+p_2)^{n_2-1}[n_1(\ x+p_2)+n_2(x+p_1\ )]$$

$$u'(x)=(x+p_1)^{n_1-1}(x+p_2)^{n_2-1}[(n_1+n_2)x+n_1p_2+n_2p_1]$$

$$v(x)=e^{-\sigma/2(x+q_1)^2(x+q_2)^2}$$

$$v(x)=e^{-w}$$

$$v(x)=-w'e^{-w}$$

$$w(x)=\sigma/2(x+q_1)^2(x+q_2)^2$$

$$w'(x)=\ \sigma/2[2(x+q_1)(x+q_2)^2+2(x+q_2)(x+q_1)^2$$

$$w'(x)=\sigma(x+q)(x+q)[2x+q_2+q_1]$$

$$\begin{cases}\dot{u}=-\frac{(u+p_1)(u+p_2)}{\tau}+(u+p_1)(u+p_2)\,f(\beta v)\,f(\lambda(u+p_1)(u+p_2))\\ \dot{v}=\ \alpha v+\chi\,(u+q_1)^{n_1}(u+q_2)^{n_2}\alpha\,f^2(\lambda(u+p_1)(u+p_2))\end{cases} \quad (1)$$

With $f(t)=e^{-(t2/2)}$ and α, β and λ are positive reels.

- The sign of χ mark the polarity of activation potential.
- The value of n proper the behavior of neuron.
- The value of p the position of spike
- The value of q the degradation of spike

The parameter of n_1 and n_2 can be identical or different, in the subsection above we give some results of different values of n_1 and n_2. The dynamic of neuron is generated by the frequency of the stimulation in this paper we take sin function as input.

$$\begin{cases}\dot{u}=-\frac{u}{\tau}+(u+p_1)(u+p_2)\ f(\beta v)\,f(\lambda(u+p_1)(u+p_2))+\sin(2\Pi*ft)\\ \dot{v}=-\alpha v+\chi\,(u+q_1)^{n_1}\ (u+q_2)^{n_2}\ \alpha\,f^2(\lambda(u+p_1)(u+p_2))\end{cases} \quad (2)$$

Figure 4 shows a behavior of signal and bounded region from two neurons.

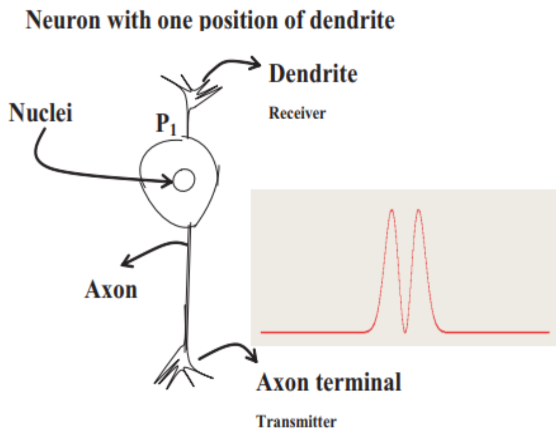


Figure 4: Neuron with one position of dendrite.

Figure 5 displays different potential functions generated by neuron with one dendrite.

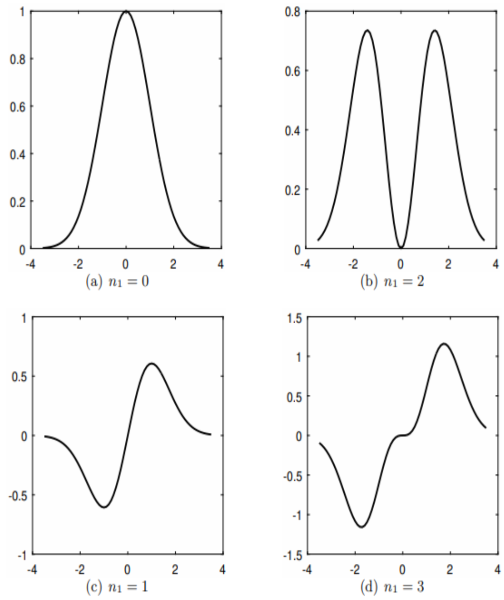
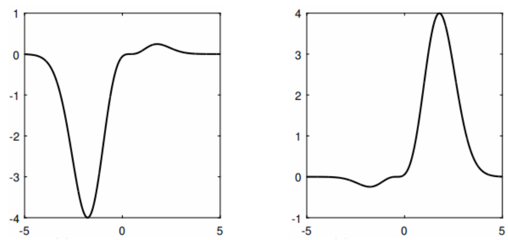


Figure5: Behavior of Neuron with one dendrite

Figure6 shows two examples of neurons polarities.



(a)Positive polarity (b) Negative Polarity

Figure 6: Neurons polarities

A.1 Neuron with two positions of dendrites

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(6), 1254-1261 | ISSN:2251-6727

$$\begin{cases} \dot{u} = -\frac{(u + p_1)(u + p_2)}{\tau} + (u + p_1)(u + p_2)\, f(\beta v)\, f(\lambda (u + p_1)(u + p_2)) \\ \dot{v} = -\alpha v + \chi\, (u + q_1)^{n_1} (u + q_2)^{n_2} \alpha\, f^2 (\lambda (u + p_1)(u + p_2)) \end{cases} \quad (3)$$

Figure 7 shows with two dendrites.

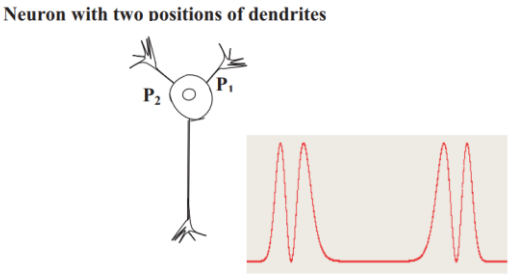


Figure7: Neuron with two positions of dendrites

A.2 Activation Function with the same behavior

In this subsection, we show that two dendrites receive the same form of signal from two synapsis.

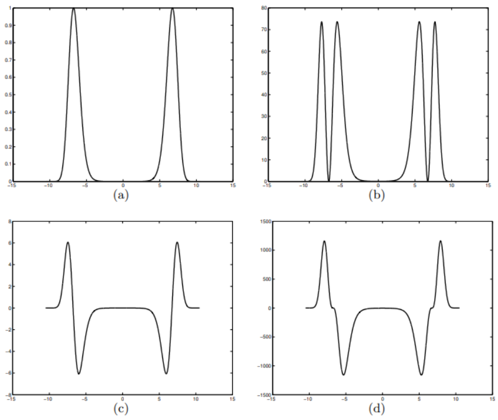


Figure 8: Behavior of Neuron with two dendrites

A.3 Activation Function with different behavior

$$\begin{cases} \dot{u} = -\frac{(u + p_1)}{\tau} + (u + p_1)\, f(\beta v)\, f(\lambda (u + p_1)) \\ \dot{v} = -\alpha v + \chi\, (u + q_1)^{n_1}\, \alpha\, f^2 (\lambda (u + p_1)) \end{cases} \quad (4)$$

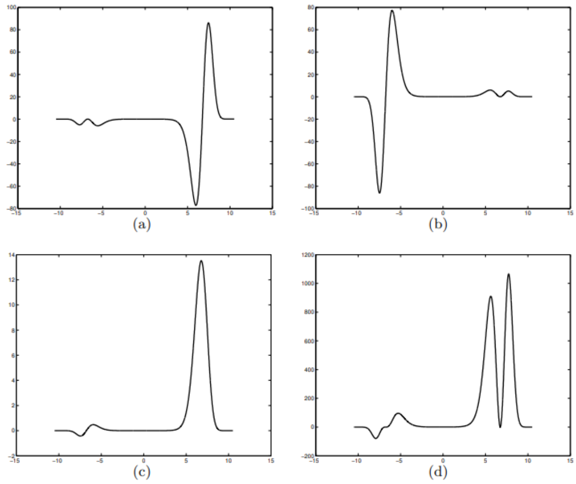


Figure 9: Four forms of signal

B. Neuron with three positions of dendrites

$$\begin{cases} \dot{u} = -\frac{(u + p_1)(u + p_2)(u + p_3)}{\tau} + (u + p_1)(u + p_2)\, f(\beta v)\, f(\lambda (u + p_1)(u + p_2)(u + p_3)) \\ \dot{v} = -\alpha v + \chi\, (u + q_1)^{n_1} (u + q_2)^{n_2} (u + q_3)^{n_3}\, \alpha\, f^2 (\lambda (u + p_1)(u + p_2)(u + p_3)) \end{cases} \quad (5)$$

Figure 10 shows with three positions of dendrites

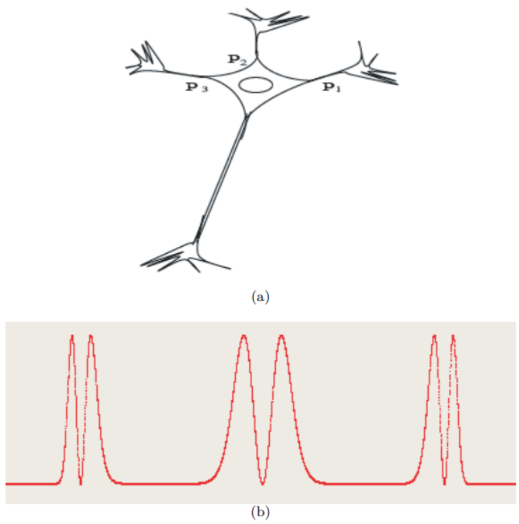


Figure 10: Neuron with three dendrites

B.1 Activation Function with the same behavior

$$\begin{cases} \dot{u} = -\frac{(u + p_1)}{\tau} + (u + p_1)\, f(\beta v)\, f(\lambda (u + p_1)) \\ \dot{v} = -\alpha v + \chi\, (u + q_1)^{n_1} \alpha\, f^2 (\lambda (u + p_1)) \end{cases} \quad (6)$$

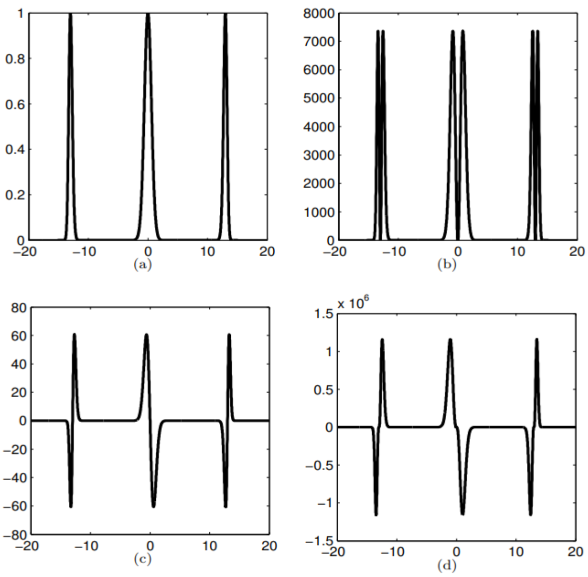


Figure 11: Behavior of Neuron with three dendrites

B.2 Activation Function without the same behavior

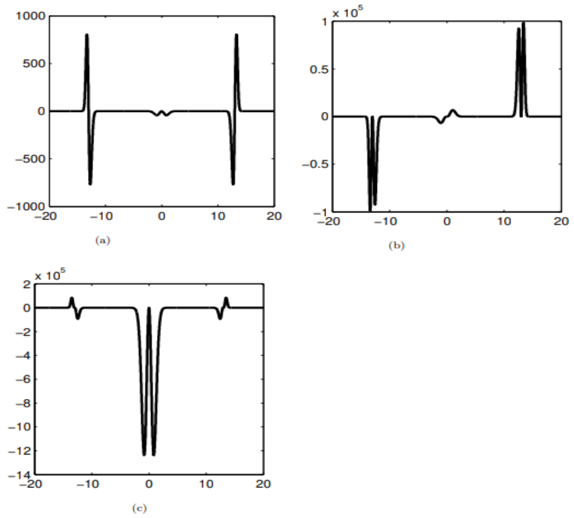


Figure12: Modulation with three neurons

4. Results

A. Potential application in neurological

Brain waves are electrical impulses in the brain. An electroencephalogram (EEG) is a test used to evaluate the electrical activity in your brain. Brain cells communicate with each other through electrical impulses. An EEG can be used to help detect potential problems associated with this activity. Our brainwaves occur at various frequencies. The classic names of these EEG bands are delta, theta, alpha, beta, and gamma.

Table 1: The five brain waves

heightFrequency band	Frequency	Brain states
delta δ	0.5-4Hz	sleep
theta θ	4-8Hz	deeply and relaxed
alpha α	8-12Hz	very relaxed
beta β	12-35Hz	active and relaxed
gamma γ	> 35Hz	concentration

The results of the EEG signals with the alpha, beta, theta and delta bands show that using our SVMN model, we can detect different diseases (Alzheimer's, stress, brain tumors, Epilepsy, etc.) in patients. Figure13 shows different example of a behavior with disorder of activation function on different position of dendrites.
Figure13 shows different example of a behavior with disorder of activation function on different position of dendrites.

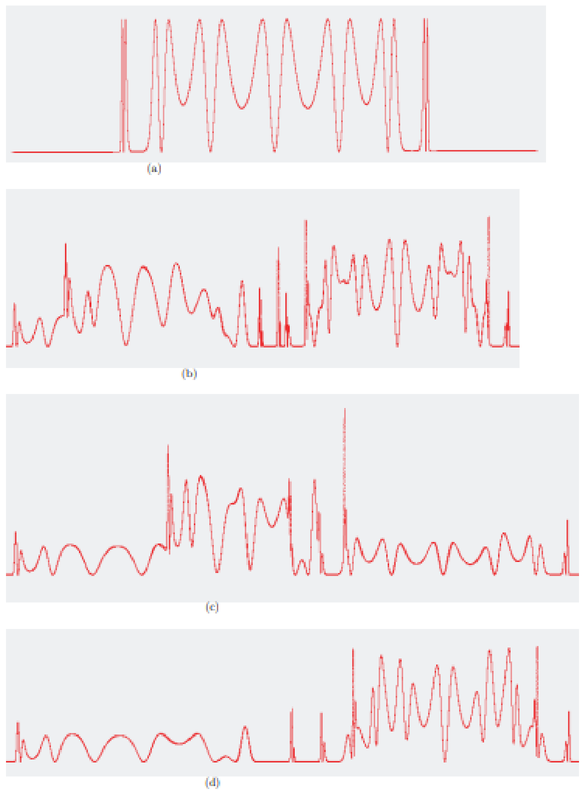


Figure 13: Brain Behavior with disorder of activation function on different position of dendrites

A. Potential application in cardiovascular

An electrocardiogram (ECG) is a test that detects and records the strength and timing of the electrical activity in your heart. This information is recorded on a graph that shows each phase of the electrical signal as it travels through your heart. The waves on an ECG include the P wave, Q wave, R wave, S wave, T wave and U wave. We use a neural network with three neurons to present the normal of ECG.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(6), 1254-1261 | ISSN:2251-6727

Figure 14 shows a normal ECG. This set of neurons contains two neurons with one dendrite and one with two dendrites:

- The first neuron generates the behavior of region P
- The second neuron which contains two dendrites generates the region of QRS
- The third neuron generates region T.

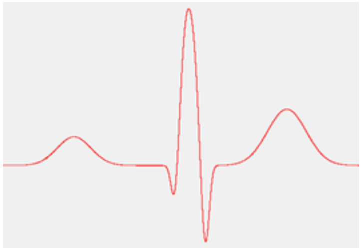


Figure 14: A dynamic behavior of ECG generated by three neurons.

Figure 15 shows degraded behavior of EEG.

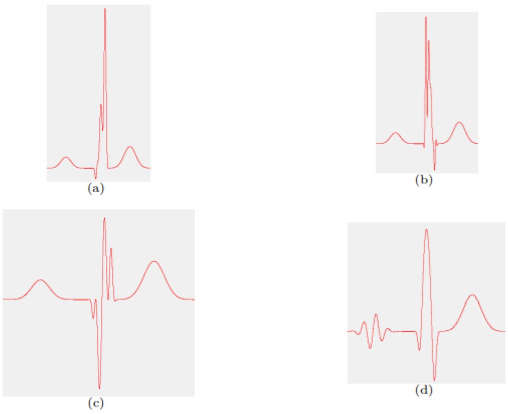


Figure 15: Heart Behavior with disorder of activation function on different position of dendrites

This simulation (Figures 14 and 15) present different perturbations to our neuron's models, each has its own activation function. A relationship between brain diseases and impaired behavior based on activation function...

5. Discussion

In this work we have explored various possibility generation of EEG and ECG using neurons of multi dendrites.

Some numerical results are provided to show the effectiveness of the work proposed in this paper. We proposed novel tools by neural network using the activation function with structures variables model to classify the brain diseases and heart diseases. We can eliminate some artifacts related to harmonics by applying an activation function with opposite polarities.

The model of brain has multi behaviors such as: oscillator, chaotic and harmonic behavior. We use a model of neuron with multi dendrites to determine the brain and heart behavior with disorder of activation function on different position of dendrites.

A. Artificial EEG generated by neuron with seven dendrites.

The methodology is presented for generation artificial EEGs and EEG sub bands for detection and analysis of disorder brain. Each artificial EEG is studied into five constituent EEG sub bands: delta, theta, alpha, beta, and gamma using a model of neuron with seven dendrites.

Position of dendrite	Value of p_i	value of q_i
1	-0.85	$+p_1$
2	-1.5	$+p_2$
3	-2	$+p_3$
4	0.85	$+p_4$
5	1.5	$+p_5$
6	2	$+p_6$
7	0	$+p_7$

During normal brain activity, the pattern of neuronal firing represented by the EEG signal is less organized and has greater complexity and chaotically.

Figures (16 and 17) shows result of implementation generated by neuron contains seven dendrites.

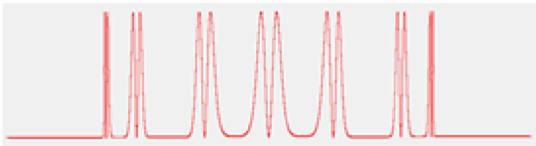


Figure 16: Neuron with seven dendrites

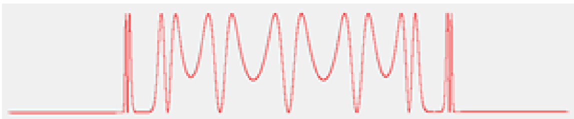


Figure 17: Neuron contains seven dendrites with close position of dendrites.

Figure 18 shows the artificial EEG generated by neuron with seven dendrites.

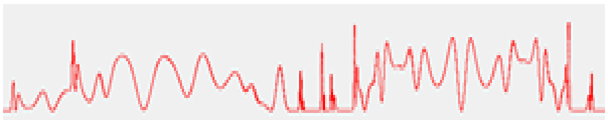


Figure 18: An artificial EEG generated by neurons with seven dendrites.

We can classify many brain diseases. Also, we can use this model to determine a behavior of heart. Figure 15 shows many behaviors of heart.

6. Conclusion

We have also given some networks by combining the neurons cited previously. In this contribution, we

discovered that neurons print their tracks in information with threshold. Some numerical simulation results are provided to show the effectiveness of the work proposed in this paper. There are some potential research directions that could be considered for the future works. We hope that these results constitute a solid theoretical foundation to build up large-scale neuron networks, reflect real aspects of functional roles in neural assemblies, and make a significant contribution to establish large-scale neuron networks dealing with the neurological diseases such as epilepsy, Parkinson's disease, Alzheimer's disease, schizophrenia, and autism in the future.

Acknowledgments
Ministry of higher education and scientific research of Tunisia support this research.

Declaration of Competing Interest
Authors of this paper confirm that there is no conflict of interest in this paper.

Credit authorship contribution statement.

Kaouther SELMI: Conceptualization, Data creation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review editing.

Mohamed BOUALLEGUE: Conceptualization, Data creation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review editing

Kais BOUALLEGUE: Conceptualization, Data creation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review editing

References

1. Haikun Weia (2008)] HAIK2008Haikun Weia, Shun-ichi Amari," Dynamics of learning near singularities in radial basis function networks",Neural Networks 21 (2008) 989-1005 20
2. M.H¨ausser (2000)] Hauss2000Michael H¨ausser, Nelson Spruston,Greg J. Stuart, "Diversity and Dynamics of Dendritic Signaling", 27 OCTOBER 2000 VOL 290 SCIENCE.
3. I.Segev(2000)]IDAN2000ldan Segev and Michael London "Untangling Dendrites with Quantitative Models", 27 OCTOBER 2000 VOL 290 SCIENCE
4. I. PARNAS (1979)] PARN79I. PARNAS AND I. SEGEV," A MATHEMATICAL MODEL FOR CONDUCTION OF ACTION POTENTIALS ALONG BIFURCATING AXONS", J. Physiol. (1979), 295, pp. 323-343
5. Chunguang & Chen (2005)] CHUNG2005 Chunguang, Li.& Guanrong, Chen. [2005]" Coexisting chaotic attractors in a single neuron model with adapting feedback synapse," Chaos, Solitons and Fractals 23, pp.1599-1604.
6. Amitava & al (2013)] AMIT13 Amitava, Kundu., Pritha, Das., A.B,Roy. [2013]" Complex dynamics of a four-neuron network model havinga pair of short-cut connections with multiple delays," Int. J. Nonlinear Dyn 72, pp.643-662.
7. Kreangkri(2007)]KREA07 Kreangkri, Ratchagit. [2007]" Asymptotic stability of delay-difference system of Hopfield neural networks via matrix inequalities and application," Int. J. Neural Systems 17,5, pp.425-430.
8. Wei Yen (2012)] WEI12 Wei-Yen, Hsu. [2012]" Application of competitive Hopfield neural network to brain-computer interface systems," Int. J. Neural Systems 22,1, pp.51-62.
9. Teijiro & al (2008)] TEI08 Teijiro, Isokawa., Haruhiko, Nishimura., Naotake,Kamiura and Nobuyuki, Matsui. [2008]" Associative memory in quaternionic Hopfield neural network," Int. J. Neural Systems 18,2, pp.135-145.
10. Burkhard and J¨org(2002)]BUR02 Lenze.,J¨org, Raddatz. [2002]" Effects of dilation and translation on a perception-type learning rule for higer order Hopfield neural networks," Int. J. Neural Systems 12,2, pp.83-93.
11. Nimet and Recai (2014)] NIME14 Nimet,Korkmaz. & Recai, Kilic. [2014]" Implementations of Modified Chaotic Neural Models with Analog Reconfigurable Hardware," Int. J. Bifurcation and Chaos 24,4, pp.11450046-1450061.
12. Jianquan & al (2008)] JIAN08 Jianquan, Lu. Daniel W. C. HO& Jinde, CAO. [2008]" Synchronization in an array of nonlinearly

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(6), 1254-1261 | ISSN:2251-6727

coupled chaotic neural networks with delay coupling," Int. J. Bifurcation and Chaos 18,10 pp.3101-3111.

13. Yuanlong & al (2014)] YUAN14 Yuanlong, Chen., Tingwen, Huang. & Yu, Huang. [1999]" Complex dynamics of a delayed discrete neural network of two nonidentical neurons," AIP Chaos 24, pp.013108.
14. Cquan and Xiao-Song (2007)] CQUAN07 Cquan,Yuan. & Xiao-Song,Yang. [2007]" computer assisted verification of chaos in three-neuron cellular neural networks," Int. J. Bifurcation and Chaos 17,12, pp.4381-4386.
15. Bouallegue kais(2017),BOUA17Kais Bouallegue, A new class of neural network and its applications, Neurocomputing 249 (2017) 28-47,
16. [I.Segev(2000)]IDAN2000ldan Segev and Michael London "Untangling Dendrites with Quantitative Models", 27 OCTOBER 2000 VOL 290 SCIENCE 21
17. Kais. Bouallegue (2012)] Kais. Bouallegue. [2012]" A new fractal model of chromosome and DNA processes," Book, Chapter. Proc. The 4th International Interdisciplinary Chaos Symposium Chaos and Complex Systems., pp.505-514.
18. J.J. Hopfield (1984)] HOPF84 J.J. Hopfield. [1984]" Neurons with graded response have collective computational properties like those of two-state neurons," Proc. Natl. Acad. Sci. USA 81,17, pp.3088-3092.
19. Qingdu, Lia & al (2005)] QING05 Qingdu, Lia. Xiao-Song, & Yangb. Fangyan, Yanga. [2005]" Hyperchaos in Hopfield-type neural networks," Int. J. Neurocomputing 67, pp.275-280.
20. RezaMazrooei-Sebdani and SaeedFarjami (2015)]REZA15 RezaMazrooeiSebdani, Saeed Farjami. [2015]" On adiscrete-time-delayed Hopfield neural network with ring structures and different internal decays: Bifurcations analysis and chaotic behavior," Int. J. Neurocomputing 151, pp. 188-195.
21. G. Lee and N.H. Farhat (2001)] GLE01G. Lee and N.H. Farhat. [2001]" The Bifurcating Neuron Network," Neural Networks 14, pp.115-131.
22. Kais. Bouallegue (2015)] KAIS15Kais. Bouallegue. [2015]" Gallery of Chaotic Attractors Generated by Fractal Network," Int. J. Bifurcation and Chaos 25,1, pp. 1530002-18.