



An Effective Approach to Equivalence the Blood Circulatory System through Human Heart with the Artificial Neural Network

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Abstract: Multi-Layered Network shows the feed forward connection characteristics in mathematical models system. Here, we focus on analysis of neocortical processing of Blood Flow from Heart to Body and vice versa. The Blood Flow in Human body always follows Non Linear Distribution Function. Here in this paper we basically try to solve the Heart Inactive problem by pushing any external trigger or to minimization the possibility of Heart Blocked or Stoked by applying neural based algorithm in this Non Linear network system

Keywords: Artificial Neural Network, Blood Circulatory System, Heart Pump Circuit, Gradient Descent algorithm, Pseudo – Inverse Approach

I. INTRODUCTION

Neural Network based on artificial statistics plays an important role in the process control schemes. The system identification of this network is developed on the basis of mathematical models that are why it can express the network in terms of multinetworks.

Now, the circulatory blood flow system through a human body from one organ to another can be realized as a neural network. The bold circulatory system in human body also known as lymph trans port system [1]. The brain of a human contains a network which inter-dependent among the blood flow system. The inter-dependent network is well co related with neural network.

Now trace on blood flow system. The oxygenated blood flow arteries to the organs and the portion of the blood that flows into the kidneys is cleaned of impurities and waste products are activated through the bladder and urethra.

De oxygenated blood [1] moves the right side of the heart at the right atrium. It is then pumped into right ventricle and out heart to the lungs the blood gives up its CO₂ and takes a fresh supply of O₂.

In this paper it have case studied on equivalence of the blood flow circulatory system from hearts to human body and vice versa with the artificial neural network models.

This also have shown that how with the basis of apply some algorithms based on neural networks to the blood circulatory system to continuing the activation of Heart Working Function continuously in any unwanted accidental circumstances in Heart if happening.

II. THE EVENTS OF ATRIAL AND VENTRICULAR IN CARDIAC CYCLE

In Cardiac Cycle there have been seen Atrial and Ventricular events. That is discussed here.

(1) **Atrial Systole :** Its timing states is around 0.1 sec. First half is Dynamic phase (The Systolation is very much high) and others half is Adynamic phase (The Systolation is happening slowly). For this systole blood is entered by pushing the Tricaspid and Bycaspid valves respectively.

(2) **Atrial Diastole :** Its timing cycle is around 0.8 sec. Blood here flows through 4 No of pulmonary vens and Superior and Inferior vena cavas to the right and left atrial. After this the Atrial Systole starts again.

(3) **Ventricular Systole :** It starts just after the Systole of Atrial. After the 1st Heart sound (0.05 sec time required after the close of Atrial – Ventricular valves) the semileunor valves open. This middle period of this closing and opening valves are known as *Isometric Contraction Period*. In this period Ventricular are compressed, so the inner membrane of ventricular feels pressure increases. In this time, the blood exits from ventricular

through the pulmonary ven and Superior and Inferior vena cavas. This period is known as ejection period. The blood flow rate at the outset very fast then the flow rate decreases. The fast period is maximum ejection period and slow period is known as reduced ejection period. Here in this phase, the *Systole of Ventricular* is stopped and *Diastole of Ventricular* starts.

(4) **Ventricular Diastole :** At the starting of this *Diastole*, the semileunor valf are closed and 2nd Heart Sound is heard. The period between closed of semileunor valf and starting of *Ventricular Diastole* is known as *Protodiastole Period*. After the 3rd Heart Sound, the the valves of Atrial and Ventricular open and the blood

flows from Atrial to Ventricular. The gap between the closed of semileunar valf and opened of Atrial-Ventricular valf is known as *Isometric Relaxation Period*. The blood flow around the ventricular consists 3 phases:-

- (a) **First Ratrid Filling Phase** - Blood flow rapidly down.
- (b) **Diastans** – Blood Flow rate slow down.
- (c) **Last Rapid Filling Phase** – The rate of blood flow increases again rapidly.

After the 4th Heart Sound the diastole of Ventricular phase is end. Then again *Systole of Ventricular* starts.

The Heart serves as a pump [1]. In the presence of electrical stimules, the heart will contract in the atria which belongs to form a shallow. A fraction of second later, the ventricles also contracts in the form of systole and diastole as discussed earlier. The Heart pumps approximately 3 to 5 litre of blood per minute.

The figure of *Cardiac Output* (CO) will be calculated as follows :

$$CO = \text{Heart Rate (Beats/ min)} * \text{Stroke Volume (L / Beat)} \dots\dots (1)$$

Stroke Volume is the volume of blood ejected from ventricles during systole.

III. TOTAL BLOCK DIAGRAM OF CIRCULATORY SYSTEM

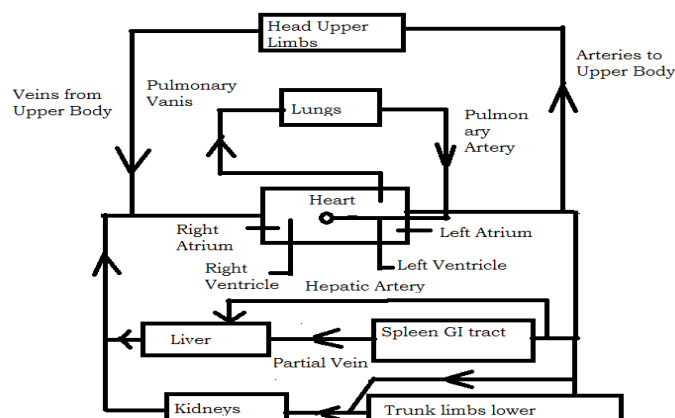


Fig.1- Block Diagram of Blood Circulatory System through Heart [Figure is taken from Human Anatomy and Physiology : 2nd Edition by James E. Cronch]

IV. MEASUREMENT OF HEART RATE

Now to measure the Heart Rate [4], a special type of frequency to voltage converter is designed. The measurement of average Heart Rate is seemed as diode pump circuit (shown in Fig.4) which is combined of series connection of R_1C_1 network with two reverse direction connected diode one of which a parallel combined of C_2R_2 network connected.

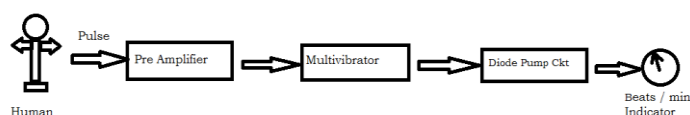


Fig.2- Block Diagram of an average Heart Rate Monitor

[Figure is taken from Handbook of Biomedical Instrumentation : 21st reprint 2002 ISBN 0-07-451725-2 By R S Khandpur]

Now, to obtain the frequency from diode pump circuit we generally follows the following formula :

The average current over a period 't' would be ,

$$i_{av} = \frac{Q}{t} = \frac{N (CV)}{t} = CVf \dots\dots\dots (2)$$

The output voltage between two resistance R_1 and R_2 is proportional to the frequency i.e inversely proportional to the time (shown in fig.3 below). If the Heart Rate becomes lowere and the pulse does not appear across R at the next particular time, the output starts in fall and finally adjust the new value.

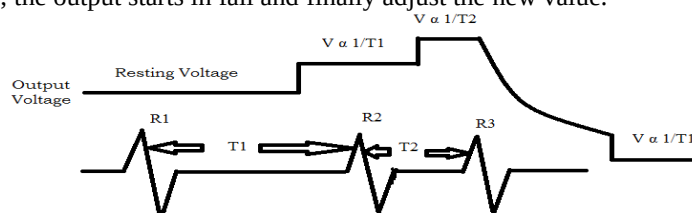


Fig.3- Principle of Frequency to Voltage Conversion

[Figure is taken from Handbook of Biomedical Instrumentation : 21st reprint 2002 ISBN 0-07-451725-2 By R S Khandpur]

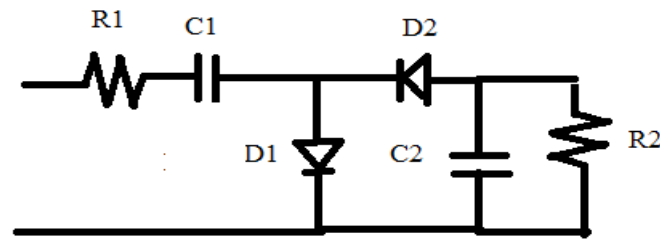


Fig.4- Diode Pump Circuit [Figure is taken from Handbook of Biomedical Instrumentation : 21st reprint 2002 ISBN 0-07-451725-2 By R S Khandpur]

V. NEURAL NETWORK FORMATION IN WORKING FUNCTION OF HEART

On the basis of Block Diagram (shown in Fig.1) it is seen that multinetwork formation in the basis of veins and aorta. When these networks are represented as a controllers or as systems models, it becomes relatively easy to perform a closed loop analysis of a control system in terms of stability and convergence. Following Fig.5(a) shows a formation of Neural Networks

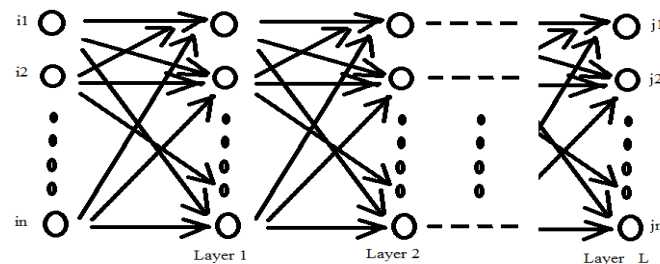


Fig.5(a) – An ‘L’ Layered Multi Input-Output Neural Networks

Comparing this network with blood flow circulatory system throughout the human body, the following diagram of Fig.5(b) is created.

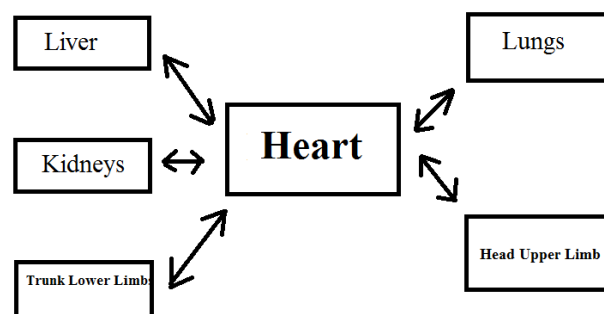


Fig.5(b) – Blood Flow system through Human Body from Heart

Now, the simplest form of an artificial neural network is called perception which is first developed by Rosenblatt in 1958 [5]

VI. PRINCIPLE OF ARTIFICIAL NEURAL NETWORK

Suppose a function $j=f(i)$ can be approximated by neural network. If the no of pattern available is ‘N’, then the cost function whose minimization is our moto, can be defined as :

$$E = \sum_{k=1}^{k=N} E^k \quad (3)$$

$$\text{where, } E^k = \frac{1}{2} |j_k^d - j_k|^2 \quad (4)$$

' j_k ' is the k^{th} actual pattern and ' j_k^d ' is the k^{th} desired pattern

Now the all pattern must have a weight factor i.e 'w'. The minimization process of cost function is basically the principle of Gradient Descent by which the weight factor 'w' should be updated by the following process.

$$w^{new} = w^{old} - \zeta \frac{\partial E}{\partial w} \quad (5)$$

ζ is Learning Rate and E should be minimum when $w = w_{min}$

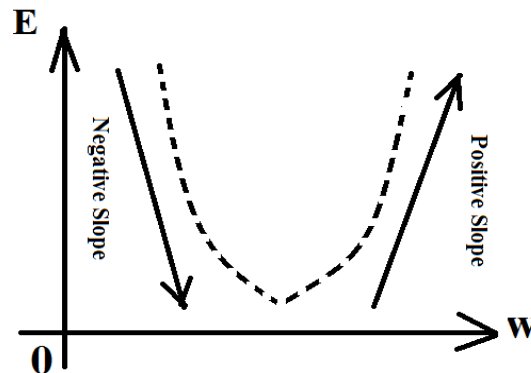


Fig.6 – Weighted updated graph by the Principle Gradient Descent Algorithm

From Fig.6, - when $w < w_{min}$, $\frac{\partial E}{\partial w}$ is negative and for that change in 'w' moves towards ' w_{min} ' to be positive value.

When $w > w_{min}$ vice versa is happened.

In both cases, the slopes of $w \rightarrow w_{min}$ depends on ' ζ '

$$\text{If, } \Delta w = w^{new} - w^{old}, \text{ then } \Delta w = -\zeta \frac{\partial E}{\partial w} \quad (6)$$

This Δw is called Batch Update.

VII. PSEUDO – INVERSE APPROACH

The *Pseudo –Inverse Approach* computes the 'w' in batch mode. The weight factor 'w' represents the basis function in terms of vector signal representation. The width of the basis function is determined by :

$$\beta = \frac{t}{\sqrt{2f}} \quad (7)$$

where 't' is the maximum distance gap of centers and 'f' is the number of centers.

Now, as per proportional rule if the basis function behaves as a constant, then the weight factor relates as, -

$$j^k = \theta^{kT} w \quad (8)$$

$$\text{where, } \theta_n^k = \exp\left(-\frac{f}{t^2} \|i^k - c_n\|^2\right) \quad (9)$$

Now, using these expression, overall pattern is represented as matrix form.

$$|\theta| \cdot |w| = |j| \quad (10)$$

$|\theta|$ is the n^{th} row vector and Transpose of $|\theta| = |\theta|^T$ can be uses to represents the Transpose of output $|j|$

$$|j| = |j_1 j_2 \dots j_n|^T \quad (11)$$

$$\text{So using eq}^n(10) \text{ and eq}^n(11), |w| = \left[|\theta| \cdot |\theta|^T \right]^{-1} \cdot |\theta|^T \cdot |j| \quad (12)$$

The R.H.S of eqⁿ(12) is called 'Pseudo –Inverse'

VIII. ELECTROCONDUCTION SYSTEM OF HEART : EQUIVALENCE FUNCTION OF MULTI NEURAL NETWORK

The Conduction of Heart basically combined of -

- Sinoatrial (SA) Node
- Bundle of His
- Atrioventricular (AV) Node
- The Bundle Branches

- *Purkinje fibers*

The SA nodes, located on the wall of right atrium in Heart provides a spark signal as a pulse by firing on its own but controlled by CNS to adjust the heart rate. In between SA node and AV node the band of specialized tissue is situated in which the velocity of propagation is faster than it is in atrial tissue. Blood in the atria is forced by the contraction through the valves to the ventricles.

Now, ventricles do not respond earlier than the atria are empty of their contents. A delay line is needed to avoid any undesired thing in the case of ventricles response. This delay line is a function of AV node

Now, if the Heart is blocked, the internal system (electro-conduction) of heart is interrupted. This undesired phenomenon can be treated as a cost function in neural network.

To minimize these function there have to follow *Principle Of Gradient Descent* algorithm.

When the SA node and AV node acts as a weightage factor equivalence to 'w' in neural network. According to this algorithm,

$$(a) : \frac{\partial E}{\partial w_n} = \frac{\partial E}{\partial j} \times \frac{\partial j}{\partial w_n} = |j^d \sim j| \cdot |\theta_n| \quad (13)$$

(b) : The Central Function of Heart is denoted by $c_n(\tau)$ mathematicaaly. The upgradation of $c_n(\tau)$ is

$$c_n(\tau+1) = c_n(\tau) - \zeta_1 \frac{\partial E(\tau)}{\partial c_n(\tau)} \quad (14)$$

$$(c) : \text{Now, } \frac{\partial E(\tau)}{\partial c_n(\tau)} = \frac{\partial E}{\partial j} \times \frac{\partial j}{\partial \theta_n} \times \frac{\partial \theta_n}{\partial c_n} \\ = -|j^d \sim j| \times w_n \times \frac{\partial \theta_n}{\partial z_n} \times \frac{\partial z_n}{\partial c_n} \quad (15)$$

$$\text{where, } \frac{\partial z_n}{\partial c_n} = -\frac{z_n}{\beta^2} \cdot \theta_n \quad (16)$$

where, β acts as a basis function as discussed earlier in section VII

The eq^n (16) is the equivalence eq^n of Least Mean Square Algorithm uses to minimization the quantized error in pulse samples.

IX. CONCLUSION

One motto in this paper is to give an idea for approach a technique of blood flow circulatory system in human body on the basis of Heart Pumping which quite equivalence of working process in artificial neural network. From the algorithm I try to create demands the minimization of possibilities any interrupted error in forms of Heart Problems.

The details about active of Heart in any situation is under research. I basically try to give an aspect of continuity of blood flow by activation of Heart Function around the long life in our system.

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