AN APPLICATION OF MULTI-INTERACTION CELLULAR NEURAL NETWORK IN EARLY WARNING FOR CARDIOVASCULAR DISEASE PATIENTS WITH ANTI-VITAMIN K

Tuyen Nguyen Tai[a], Hoan Nguyen Quang[b]
[a]Lab Center, Posts and Telecommunications Institute of Technology, Hanoi City Vietnam, tuyenntptit2010@yahoo.com
[b]Hung Yen University of Technology and Education Hung Yen City Vietnam, quanghoanptit@yahoo.com.vn

Abstract—This paper presents an application of high-order multi-interaction cellular neural network [1][4] in early monitoring and surveillance, applied to cardiovascular disease patients resistant to vitamin K [2][3]. The algorithm is developed based on the real situation. On the recommendation of specialists in the treatment of cardiovascular disease and patients on the use of antitoxin K products. The article also presents an overview of algorithmic experiments, which are installed on smartphone platforms and smart-watches [5] for cardiac patients with artificial valve replacement for ease of follow-up during treatment and administration, to reduce the risk of blood clots, blockage, artificial valve closure, and stroke with different ages. It is to help people feel more secure in taking vitamin K throughout their lives.

Keywords-artificial heart valve, heart valve disease, MiCNN, MiCH

I. INTRODUCTION

A. *The structure of the neural elements of the standard cells*

In the cellular neural network (CNN) [1][4] each cell C_{ij} with i is the number of rows, j is the number of columns links with neighboring cells C_{kl} in neighboring N_r (i, j) of radius r (r is a positive integer). Each cell is an input processor v_{uij}, state $v_{xij}(t)$, the output $v_{yij}(t)$. Dynamical equations describe the structure of a cell neural as follows:

$$C\frac{dv_{xij}(t)}{dt} = -\frac{1}{R_x}v_{xij}(t) + \sum_{C(k,l)\in Nr(i,j)} A(i,j;k,l)v_{ykl}(t) + \sum_{C(k,l)\in Nr(i,j)} B(i,j;k,l)v_{ukl} + I \quad (*)$$

Output function (*):

$$v_{yij}(t) = \frac{1}{2}\left(\left|v_{xij}(t)+1\right| - \left|v_{xij}(t)-1\right|\right)$$

Input signal: $v_{uij} = E_{ij}$

The conditions $\left|v_{xij}(0)\right| \le 1$; $\left|v_{uij}\right| \le 1$

Other theories A(i, j; k, l)=A(k, l; i, j) and C>0; Rx>0

With $1 \le i,k \le M; \quad 1 \le j,l \le N$

Where M, N is the size of the network [1]

1) Stability of cellular neural network

Leon O. Chua have proposed Lyapunov function:

$$E(t) = -\frac{1}{2}\sum_{(i,j)}\sum_{(k,l)} A(i,j;k,l)v_{yij}(t)v_{ykl}(t) + \frac{1}{2R_x}\sum_{(i,j)} v_{yij}(t)^2 - \sum_{(i,j)}\sum_{(k,l)} B(i,j;k,l)v_{yij}(t)v_{ukl} - \sum_{(i,j)} Iv_{yij}(t)$$

Conditions and demonstration of the network stability have been referred in [1]

2) The structure of multi-interactive cellular neural network

Multi-interactive cellular neural network is associated with the sum of the controlling links and basic feedback to

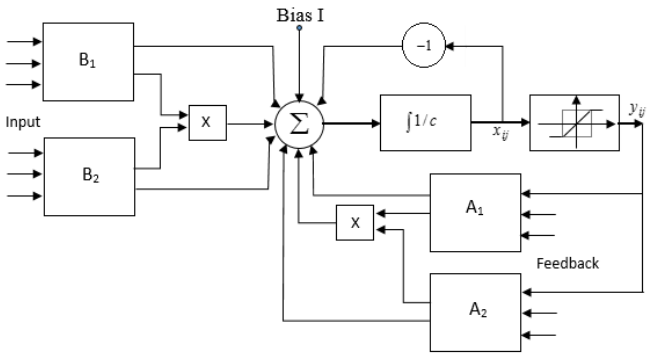

Fig 1. Network block diagram

i-1,j+1	i,j+1	i+1,j+1
i-1,j	i,j	i+1,j
i-1,j-1	i,j-1	i+1,j-1

Fig 2. *Cellular Neural Network 3x3*

the sum of the input controlling signal accumulations and the output sum of the feedback signal accumulations at any point (k,l) and (m,n) in the vicinity of the point (i,j).

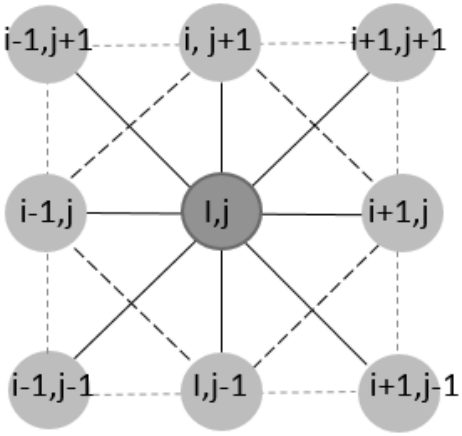

Fig 3. Connections of each neural in the CNN

Multi-interactive cellular neural network is associated with the sum of the controlling links and basic feedback to the sum of the input controlling signal accumulations and the output sum of the feedback signal accumulations at any point (k,l) and (m,n) in the vicinity of the point (i,j). Dynamical equation for multi-interactive cellular neural network as follows:

$$C\frac{dv_{xij}(t)}{dt} = -\frac{1}{R_x}v_{xij}(t) + \sum_{C(k,l)\in Nr(i,j)} A(i,j;k,l)v_{ykl}(t)$$

$$+ \sum_{C(k,l)\in Nr(i,j)} B(i,j;k,l)v_{ukl} + I$$

$$\sum_{C(k,l),C(m,n)\in Nr(i,j)} A(i,j;k,l,m,n)v_{ykl}(t)v_{ymn}(t)$$

$$+ \sum_{C(k,l),C(m,n)\in Nr(i,j)} B(i,j;k,l;m,n)v_{ukl}v_{umn}$$

$$v_{yij}(t) = \frac{1}{2}\left(\left|v_{xij}(t)+1\right| - \left|v_{xij}(t)-1\right|\right)$$

Where:

A (i,j, k,l, m,n) and B (i,j, k,l, m,n) is the ratio of the accumulation of the two feedback signals from the output and controls at point respectively (k,l) and (m,n) at point (i,j). The input signals, assumptions and similar binding conditions (*).

3) Stability of output state

The problem in multi-interactive cellular neural network is that the network state must be stable to be able to put in the application.

Consider the largest state:

$$V_{\max} = \max_{(i,j)}\left\{1 + R_x|I| + R_x \sum_{C(k,l)\in Nr(i,j)} \left(\left|A(i,j;k,l)\right|\right) + \right.$$

$$+ R_x \sum_{C(k,l),C(m,n)\in Nr(i,j)} \left(\left|A(i,j;k,l;m,n)\right| + \right.$$

$$\left.\left. + \left|B(i,j;k,l;m,n)\right|\right)\right\}$$

It is necessary to prove limited state (stability of output state). Conditions and demonstration of the stability of the network have been referred in [1].

B. The use of anti-vitamin K drugs

- Anti-vitamin K (anticoagulant-resistant vitamin K) is an oral anticoagulant, used to treat and prevent thrombosis in blood vessels. It helps prevent thrombosis from forming and increasing in size, without thrombosis such as Sintrom (Acenocoumarol) and Coumadin (warfarin).
- Anti-vitamin K works by inhibiting the synthesis of vitamin K-dependent coagulation factors (including elements II, VII, IX and X) in the liver. In the body, vitamin K is needed to participate in the synthesis of blood clotting factors to help prevent bleeding.

1) When are the anti-vitamin K agents prescribed?

Patients who have had a artificial valve replacement need to take anticoagulant for a lifetime to maintain the valve's operation, avoiding valve clots due to a clot that causes valve damage.
- Patients with arrhythmias (atrial fibrillation) easily clot in the heart. This blood clot is contracted by the heart, drifting through the bloodstream to cause a stroke (cerebral infarction). Therefore, patients with atrial fibrillation should take anticoagulant to prevent stroke.
- Patients with vein thrombosis need anticoagulants for 3 to 6 months or longer depending on the cause of the thrombosis. Patients with pulmonary embolism, primary pulmonary artery hypertension should be treated with long-acting anticoagulants.

2) How to use anti-vitamin K?

- Drinking at the right dose of the doctor, the anti-vitamin K drugs can be broken down to facilitate the division of doses.
- Do not take medication or give others medication without doctor's prescription.
- Should take anti-vitamin K drugs at a certain hour of the day / week / month depending on the dosage specified by the doctor.
- Continuing medication should be given to the day of follow-up visit (no quit or no prescription).
- The physician determines the dose of anticoagulant in each patient based on the time of blood clotting through the INR test with the required range (2.5 to 3.5 for artificial cardiopulmonary valves and 2 - 3 in the other cases). Patients need to adhere to the recommended dose and time of INR test (usually 2-4 weeks). Avoiding overdosage can cause bleeding or too low a dose that can cause blood clots or blood clots to constrict or trap artificial valves.

3) If patients forget to take medication

Take the missed dose as soon as they remember if they forgot within 8 hours since the time of taking medication every day.
If they forget to eat more than 8 hours, skip the dose and wait for the next dose.
- Do not take double dose to compensate for missed dose.
- Tell their doctor if they forget their medications immediately after forgetting or when they come back for a follow-up visit.
- If they forgot 2 consecutive times, they should consult the doctor's instructions.

II. PROBLEM SOLVING

Relying on the strict requirements for the use of anti-vitamin K drugs for patients, the results of the application must meet the following requirements:

- Patients taking the vitamin K must take the correct time frame of the day / week / month / year and use the drug with a lifetime of artificial valve.
- Patients often forget to be reminded to take medication when it is time to take medication.

+ Alert with ringing or music or speech for 1 minute and 4 minute interruptions then report several times in about 1 hour.

If the patient drinks the drug, it will confirm medication by turning off the alarm.

+ If the patient does not take the medication, the warning will be repeated 1 minute and 5 minutes and will last for 1 hour,

+ After 1 hour, if it is not confirmed, the message at the rate of 1 minute and 10 minutes of interrupt (this time the sound of higher frequency to distinguish from 1 hour ago), alert with ringing or music or speech will be continuous for one hour.

+ After one hour, if it is still not confirmed, the message is announced at the rate of 1 minute and 15 minutes of interrupt (this time the sound is higher and the frequency of the second time is different from the time 1 and 2 hours notice, alert with ringing or music or speech will be continuous for one hour, and then send short messages to the phone of the patient's family to remind patients' family.

+ The warning procedure is repeated from the 4th to the 7th times, with high frequency and urgency for patients taking the medication. If the seventh is still not confirmed, the program must inform family members and family doctor about quitting so that family and family doctor plan to monitor and test the blood coagulation rate after quit taking medication.

- If they forget to quit or stop taking medication because the medicine is over for more than 8 hours. The medication has not been confirmed. The program must inform family members and family doctor about quitting so that family and alert with ringing or music or speech plan to monitor and test the blood coagulation rate after quitting.

III. HIGH-ORDER MULTI-INTERACTION CNN IN EARLY WARNING FOR VITAMIN K-RESISTANT PATIENTS

A. *Flowchart*

Step 1. Start (initialize the program)
Step 2. Enter alert and warning sound information, alert and audio alerts, phone numbers for alert messages, and online storage addresses on the use of antiviral medications K.
Step 3. Medication time frame
- If it is confirmed that they have taken medication, send information stored and stop the notification
- If it is not confirmed that they have taken medication, go to step 4

Step 4. Prompts to take the medicine at 1/4 rate are repeated continuously for 6 times.
- If it is confirmed that they have taken medication, send information stored and stop the notification
- If it is not confirmed that they have taken medication, move to Step 5

Step 5. The prompts for 1/4 of the dose is repeated six times, the sound frequency is 6 times higher than the last hour.
- If it is confirmed that they have taken medication, send information stored and stop the notification
- If it is not confirmed that they have taken medication, go to step 6

Step 6. Prompts to take 1/4 medicine repeatedly for 6 times, mixing frequency between 1 hour and 2 hours.
- If it is confirmed that they have taken medication, send information stored and stop the notification
- If it is not confirmed that they have taken medication, go to Step 7

Step 7. Notice of 1/4 dose is repeated continuously for 18 times, mixing frequency between 1 hour and 2hours and 3 hours.

- If it is confirmed that they have taken medication, send information stored and stop the notification. Send SMS notification to family and physician.
- If it is not confirmed that they have taken medication, go to Step 8

Step 8. Keep the information for patients who have quit and do not drink again after 8 hours as instructed by their doctor by text message and audio message.
- If it is confirmed, information is sent, stop the notification
- If it is not confirmed that they have taken medication, send audio and text messages to family members and family doctor.

Step 9. Finish

B. Function block diagram

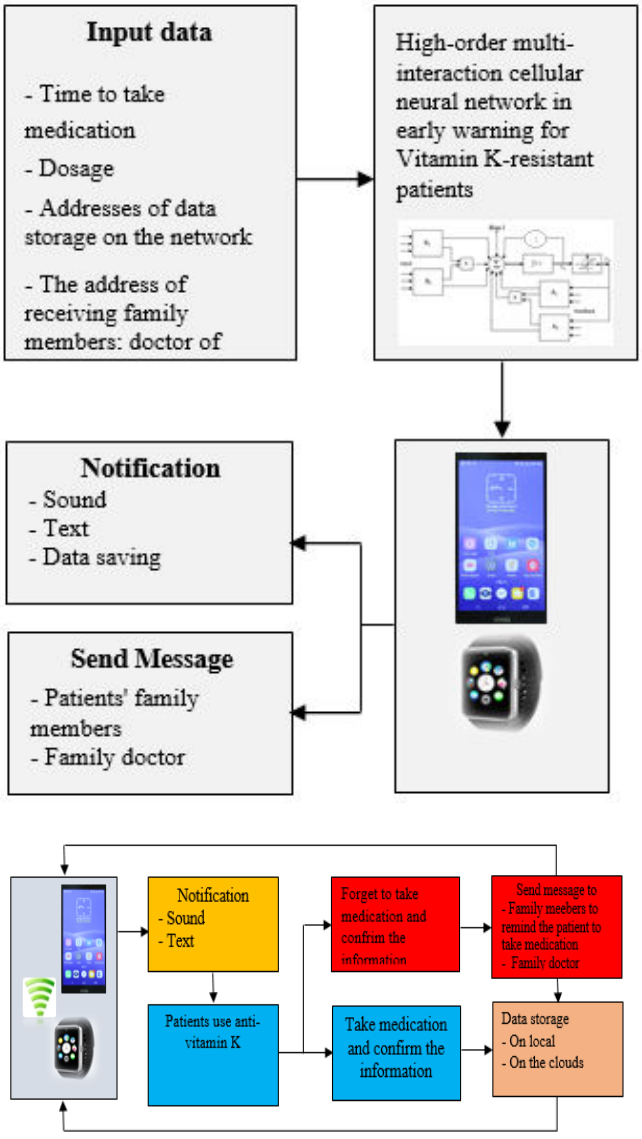

Fig 4. *Function block diagram of MiCH*

IV. EXPERIMENT RESULTS

The program has been experimented with a number of basic functions such as reminding patients to take medication with a dial tone, speech and messages on the screen prompting the prescriber's prescription dosage for each time / day / week / month. Speech and text messages on the screen, message to the patient's family about the addition of anti-vitamin K to ensure that the drug is always enough to meet the treatment of the doctor for patients. Due to the specificity of patients replacing artificial cardiac valves, patients must take life-saving anti-vitamin K antipsychotics without the need to discontinue their medication without having to take prescription medications and regular checkups blood through the INR. The program also monitors the heart rate and blood pressure data and INR tests weekly and monthly to provide early warning for patients and physicians. Experimental results show that 99.7% of the time the doses are taken at the doctor's discretion, and there are no cases of quitting due to forgetfulness or withdrawal of medication.

V. CONCLUSION

This article presents the results of the application of high-order multi-interaction cellular neural network in early warning and monitoring for cardiovascular disease patients resistant to vitamin K. The algorithm was developed, installed on smartphone and smart-watch. The application for cardiac patients replaced by artificial valve aims at monitoring during the treatment and use of drugs, helping patients to use medication on time and the right dose, to avoid mistaken drug dosage of each time per / day / week.
The program was implemented by a team at the Lab Centre, Posts and Telecommunications Institute of Technology, Vietnam - PTIT; The Institute of Electronics, Computer Science, Automation (VIELINA) performs a multi-interactive neural network neural network based mobile device platform.

REFERENCES

[1] Nguyen Tai Tuyen, *On a Structure of High Order Multi-Interaction Cellular Neural Network*, international journal of advanced computational engineering and networking, Volume-4, Issue -2, Feb-2016, Page 24-

[2] Family doctor Association, Ho Chi Minh City, Vietnam, *Health handbook for patients with heart disease*, Medical Publishing House, Vietnam 2016

[3] Pham Nguyen Vinh, *Su dung va theo doi lau dai thuoc khang dong tren benh nhan thay van tim*, 14th Vietnam national congres of cardiology 2014.

[4] Posts and Telecommunications Institute of Technology, http://www.ptit.edu.vn.

[5] https://www.visualstudio.com/downloads/.