The automatic blood -pressure control during Surgery using the fuzzy logic

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Abstract

In this research has been investigated the fuzzy logic strategy to adjust the arterial effective pressure through intravenous infusion with Proside Nitro Sodium. There is an increase with blood– pressure at cardiac patients after surgery. The goal is to create a automatic control system which it can decrease the blood - pressure pendulous variations rapidly by the injection of proside nitro sodium. In this research has been used of the fuzzy controller to deter mine the infusion rate and value of proside nitro sodium and to stabilize the blood-pressure daring one minute.

Keywords: Blood-pressure control; fuzzy controller; arterial effective pressure; Proside Nitro Sodium drug.

1. Introduction

Nowadays the automatic control play a important role in the modern medicine the blood – pressure control is one of the importance control applications in medicine. Many researchers have researched about this topic.L.C.Sheppard [1] used a PID controller to control the blood- pressure. but this controller could not have a high performance to react into the hypertensive drugs in little difference. The adaptive control was investigated by B.Widrow [2] and J.M.Amsparger and et.al [3].But this was not a high performance. A.J.Koivo[4] organized a blood – pressure control system based on the optimum control which could maintain the blood- pressure in a low level but the blood- pressure range that could be considered as a reference was low . T.Masuzawa and Y.Fukui[5] used the fuzzy logic to control blood- pressure which it could control the blood- pressure in a high level in some medicine application but the vibration simply could be appeared in reaction because they had not considered the presence of the died time in reaction dunning the design phase[6]. The following has been investigated three dynamic control models.

2. Developed dynamic control models

2-1:The blood- pressure system dynamic model by Johnnie W.Huang [7] , is expressed into the below relation at 1980

$$MAP = P_0 + \Delta MAP + P_D + n \qquad (1)$$

MAP**:** arterial effective blood- pressure.

ΔMAP: primary blood- pressure.

P_d : : blood- pressure variations during ranine reaction, which is the body reaction into using of Proside Nitro Sodium drug

P_0: primary blood- pressure.

ΔMAP can be applied to decrease the blood-pressure of the patient optimally daring the drug infusion with different rates.

2-2 : The blood- pressure system dynamic model by Meng Joo Er,Yang Gao[8] is expressed with the below relation at 1980.

$$\begin{aligned} y(t_s) &= F[y(t_s-1),u(t_s-d),u(t_s-m)] \\ &= a_0 y(t_s-1)+b_0 u(t_s-d)+b_1 u(t_s-m)+u(t_s) \qquad (2) \end{aligned}$$

$y(t_s)$: it is the output of the system ,which it is the infusion rate at the sample time(t_s).

$u(t_s)$: it is the input of the system ,which it is the infusion rate at the sample time(t_s)

d ,m which is $d<m$: these are the retardations with the amount of integer, which show the primary time , respectively.

α_0‘b_0 ¸b_1: these are the parameters which may change in a patient under different conditions.

$u(t_s)$: is the unknown conditions of the disorder which may be included, the non-model dynamic, disorder the noise of measurement the effects after sampling from time consecutive signals. The parameters of α_0،b_0 ,b_1 have been assumed to be constant. Therefore they are led to a linear system.

2-3: The blood-pressure dynamic model in response to SNP infusion rate by J.B.Slate et al [9]. Is expressed as below at 1979.

$$MAP=MAP_0+\Delta MAP+MAP_R \qquad (3)$$

Which MAP is the arterial effective pressure , and MAP_0 is the primary blood- pressure, and, ΔMAP is the blood-pressure variations during infusion drug and MAP_R is the device noise. The variance of MAP_R as sample , is 4 (for normal noise level) or ,16 to 36 (for high noise level).

The description of the conduction function , is the relation between the blood-pressure variations and the rate of the drug infusion which it is expressed as below formulation

$$\frac{\Delta MAP(S)}{SNP(S)}=\frac{Ke^{-t_i s}\,(1+\alpha e^{-t_c s})}{1+\tau s} \qquad (4)$$

Which ΔMAP is the change in blood-pressure and SNP(S) is the speed , of the drug infusion , and k is the patients sensivity into the drug and a is the recirculation constant , and T_c is the recirculation time retardation and t_i is the primary conduction from infusion spot, and is the true result of time late from the drug administration and distribution .K(1+α) is the constant interest response. We will investigate the proposal model of this research in next section, which it has been inspired in to these three models.

3. Proposal model :

In this model is simulated the patient blood- pressure variations by simulation of the automatic drug-processing system and the controller calculate the infusion rate of the proside nitro sodium drug, and it has been used from below equation:

$$\frac{\Delta MAP(s)}{SNP(s)}=\frac{Ke^{-T_{ik}s}(1+\alpha e^{-T_c s})}{(1+T_{id}s)(1+\tau s)} \qquad (5)$$

Which ΔMAP(s) is the system input and the blood- pressure variation, and SNP(S) is the system output and the drug infusion rate ,and K is the patients sensvity into the drug and α is the recirculation constant , T_c is the recirculation time retardation, and T_i is the primary conduction (administration) retardation from infusion spot , and τ is the true result of time late from the drug administration and distribution K(1+τ) is the constant interest response. It has been selected the equation parameters in this model as below:

$$y(s) + y(s)\,\tau\, s + T_{id} s y(s) + T_{id}\tau\, s^2 y(s) = u(s) k e^{-T_{ik} s} + u(s) k\, \alpha\, e^{-(T_{ik}+T_c)s}$$

$$\rightarrow \quad y(t) + \tau \frac{dy(t)}{dt} + T_{id}\frac{dy(t)}{dt} + T_{id}\,\tau d^2y(t)/dt^2 = ku(t-T_{ik}) + k\alpha u(t-T_{ik}-T_c)$$

$$\rightarrow \quad T_{id}\,\tau\;\; d^2y(t)/dt^2 = -y(t) - (\tau + T_{id})\frac{dy(t)}{dt} + ku(t-T_{ik}) + k\alpha u(t-T_{ik}-T_c)$$

$$\rightarrow \quad 800\; d^2y(t)/dt^2 = -y(t) - 60\frac{dy(t)}{dt} - 0.25u(t-20) - 0.025u(t-65) \qquad (6)$$

In next section has been investigated the system simulation , at first, without the use of controller and then using of the fuzzy controller long with their output [10].

3-1-The system simulation not using controller

In first simulation section, has been used the equation system without controller. The designed simulink to system is as below:

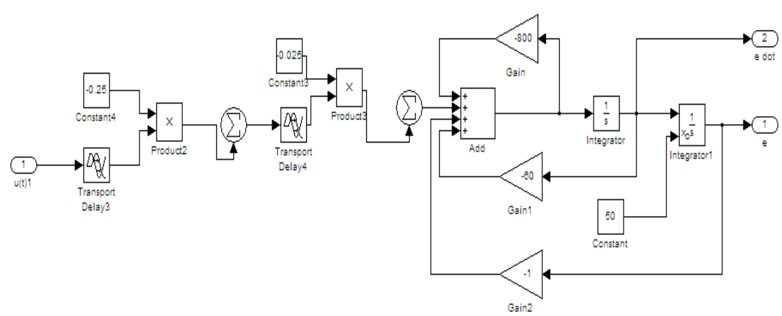

Figure 1. The system simulink

And the system output is shown below:

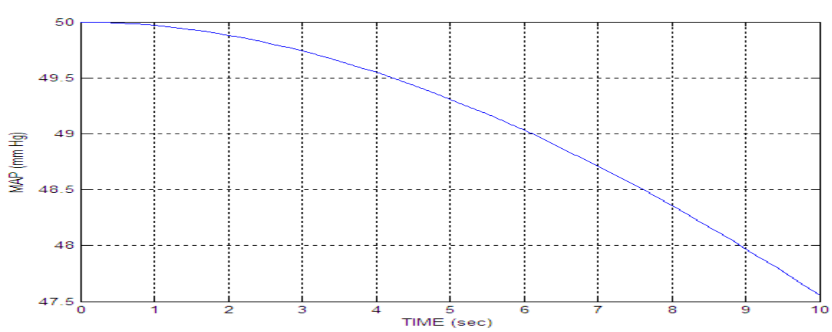

Figure 2. The system output not using controller

3-2-The system simulation using the fuzzy controller

In second simulation section, at first , has been designed the fuzzy controller , which it is including two inputs namely e and ė which are the blood –pressure variations and the difference of the blood – pressure variation, respectively, and the controller output is the infusion rate of proside nitro sodium drug.

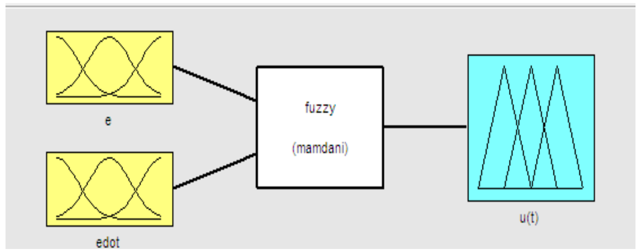

Figure 3. The fuzzy controller inputs and output

The total fuzzy terms for e input, are composed of three fuzzy membership function namely normal (n) ,positive (p) and positive big(PB) .

These fuzzy situations have been defined under the subset of the true numbers (0, 80). Also the total fuzzy terms for ė input are composed of three fuzzy membership function namely normal (N) zero(Z) and positive (P). These fuzzy situation have been defined under the subset of the true numbers(-1,1).

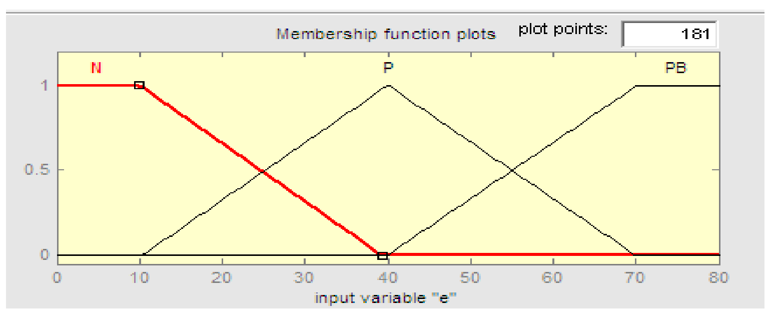

Figure 4. The fuzzy controller e input membership function

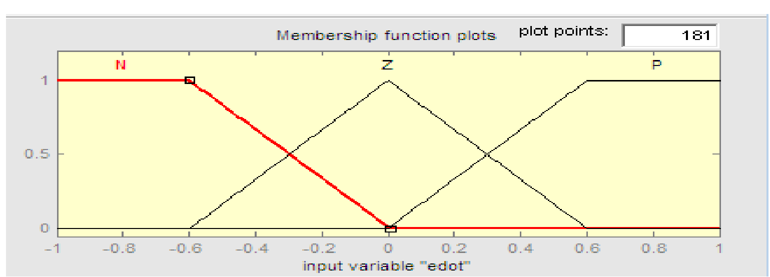

Figure 5. The fuzzy controller ė input membership function

The total fuzzy terms for u(T) output are composed of five fuzzy member ship functions namely very low (VL) , ZIRO (Z), low(L), high(H) and very high(VH) . These fuzzy situations have been defined under the subset of the true number (0, 40)

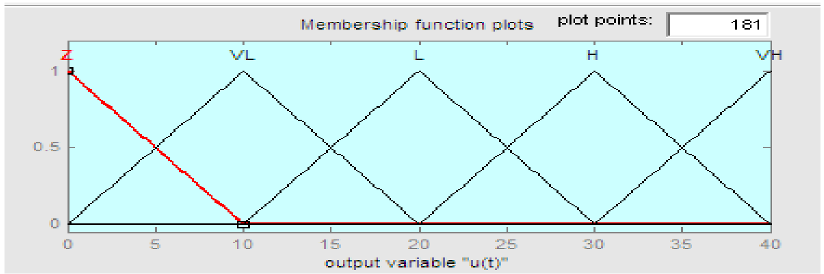

Figure 6. The fuzzy controller output membership function

The fuzzy controller ruler:

The total fuzzy rules of this controller including 9 fuzzy rules which have been defined as following:

1. If (e is N) and (ė is N) then (u (t) is L)

2. If (e is N) and (ė is Z) then (u (t) is L)

3. If (e is N) and (ė is P) then (u (t) is VL)

4. If (e is P) and (ė is N) then (u (t) is L)

5. If (e is P) and (ė is Z) then (u (t) is Z)

6. If (e is P) and (ė is P) then (u (t) is L)

7. If (e is PB) and (ė is N) then (u (t) is H)

8. If (e is PB) and (ė is Z) then (u (t) is H)

9. If (e is PB) and (ė is P) then (u (t) is VH)

The output of this designed controller has been showed in the following figure:

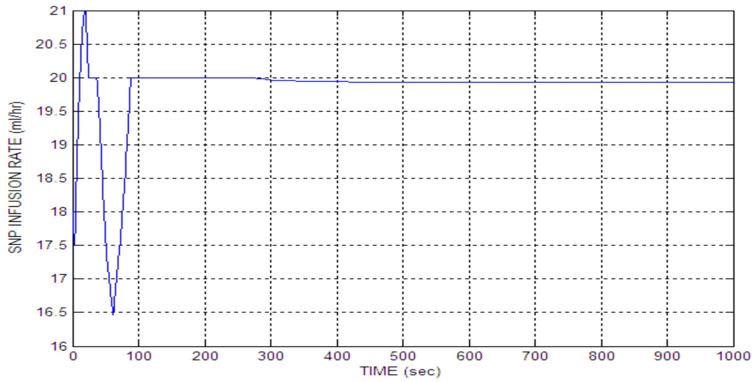

Figure 7. The fuzzy controller output

As showed, the controller output has the rapid and sudden variations, which it cannot be treated to the patient practically and clinically.In next section, this controller will be used and its result will be investigated.

3-3-Using of controller in the system

By employing the controller in the system, the normal level of the blood pressure difference is decreased to zero, namely , this controller can control the patient blood- pressure as well.

The used simulink model has been showed in figure 8:

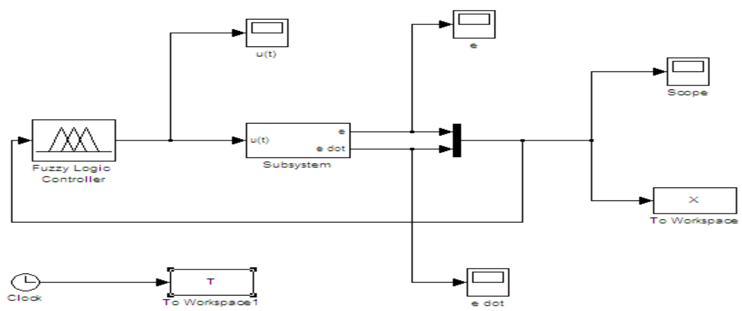

Figure 8. The system simulink using controller

and also the system output after using of controllers, has been showed in figure 9.

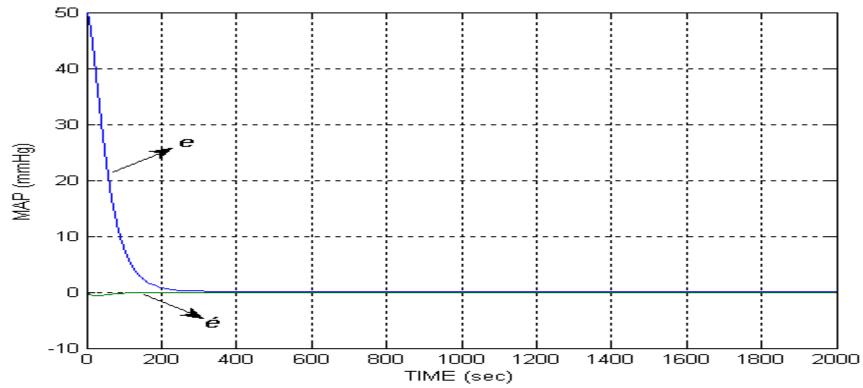

Figure 9. The system output using controller

As showed, it is controllers the patient blood-pressure at the time of almost 3 minutes and then it turn back to it's normal level.

The system response is desirable for using the controllers, but the controlling input has sudden and rapid variations which it cannot be input has a sudden and rapid variation which it can be treated to the patient practically and clinically.

For solving of this problem, has been designed a filter and it is applied to the controller output signal that it can filter the high frequencies in the controller output and also it can create a flat and smooth controlling signal. It will be described the controller improve went in the next section.

3-4-The controller improvement and final system output

For improvement of the controlling signal is used a sub-pass filter, this filter can filter the rapid variations and high frequency signal and can also create a flat and smooth output. The designed simulink bas been showed in figure 10.

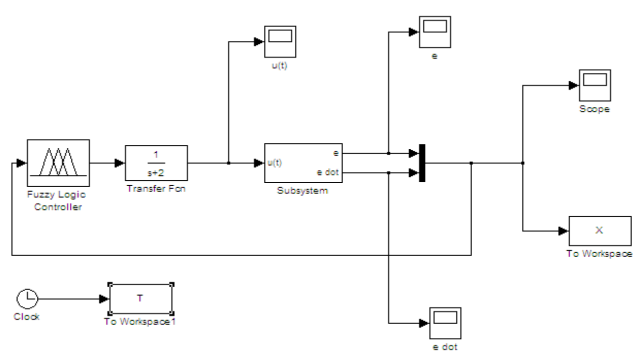

Figure 10. The system simulink using the filtrated controller

With designing a filter for the controller, the controller response has been showed in figure 11.

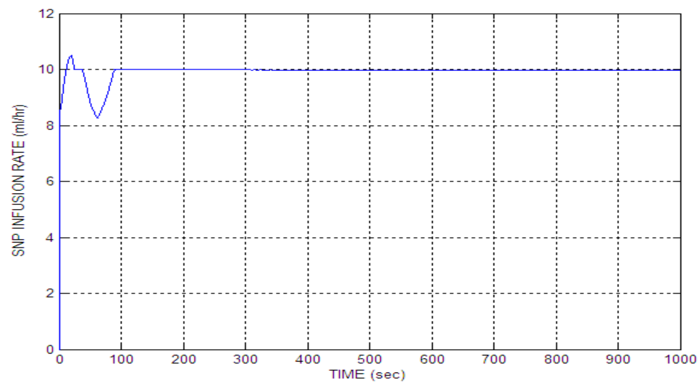

Figure 11. The system output using the filtrated controller

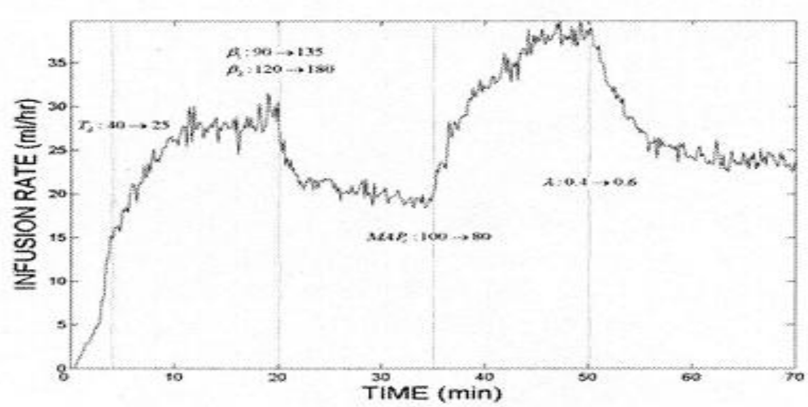

Figure 12. The system output with a IP controller

The showed diagram has used a PI controller based on MMAC (Multiple Model Adaptive Control) system, and it maintain the patient blood – pressure level as constant at almost time of 45 minutes and also its controller output has a rapid variation and the drug infusion rate is stabilizes at . Almost time of 55 minutes, but as shows, in the output diagram of proposal model, the drug infusion rate is stabilized at almost time of 1 minute.

4. conclusion

It is very complex to obtain a mathematical model due to several factors such as the nature of being non-linear of the output and input response, challenging with the drugs the response response variations from a patient to other, and the variations in a patient under different conditions.

But the fuzzy control is less dependence to the mathematical model of system. Also, it has eliminated one of the major problems in the classical control methods against with the biological system namely their intensive dependence to the model parameters by using the fuzzy control technique. The fuzzy control show an acceptable response against the lack of pragmatism, and the fuzzy controller has a more acceptable operation in comparison with other controllers.The controller output has a rapid has a rapid variations and high- frequency, which use of an integral filter is. Caused to improve the controller and to eliminate high frequencies.

It is reasonable. To the infusion rate of Proside Nitro Sodium drug which is proposed by controller.

References

[1]. L.C.Sheppard, " Computer control of the infusion of vasoactive drugs", Ann.Biomed.Eng.,vol.8,pp.4 3 1 4 ,1980.

[2]. B.Widrow , "Adaptive model control applied to realtime blood-pressure regulation",Black C Ed,Pattern Recognition and Machine Learning. McGrawHill, Berlin,1985,pp.310-324.

[3]. J.M.Amsparger,B.C.McInnis,J.R.Glover,and N.A.Nomann, "Adaptive control of blood pressure", IEEE Trans.Biomed.Eng.,vol.BME-30,no.3,pp.168-176,1983.

[4]. A.J.Koivo, "Automatic continuous-time blood pressure control in dogs by means od hypotensive drug injection", IEEE Trans.Biomed.Eng.,vol.BME-27,no.10,pp.574-581,1980

[5]. T.Masuzawa and Y.Fukui, "The control system for physiological system-optimal control of blood pressure by using vaso-active drugs", JSPE(in Japanese), vol.55,no.2,pp.406-411,1989.

[6]. Jin Feng,Qu Bo and Zhu Kuanyi ," Implementation of Drug Delivery system for blood pressure regulation", 2006.

[7]. J.B.Slate,L.C.Sheppard,V.C.Rideout,and E.H.Blackstone," A model for design of a blood pressure controller for hypertensive patients", Ph.D.dissertation,Univ. Wisconsin-Madison,no.8028208,1980.

[8]. J.B.slate," Model-Based Design of a controller for Infusing Nitroprusside During Postsurgical Hypertensive",Ph.D Thesis,Univ.Wisconsin-Madison,1980.

[9]. J.B.Slate et al., "A model for design of a blood pressurecontroller for hypertensive patients" ,presented at the sth IFAC Symp.Ident.System Param. Est. ,Darmstadt.Federal Republic of Germmany,Sept.24-28,1979.

[10]. S.Isaka and A.V.Sebald , "AN ADAPTIVE FUZZY CONTROLLER FOR BLOOD PRESSURE REGULATION", Department of Applied Mechanics and Engineering Sciences University of California,San Diego,1989.