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Soft Computing ENGG6570 **Homework-2** 2021/06/09

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Question 1: Give a discussion of the parameter sensitivity of the Neural Transmitter Model, by multiplying **Alfa** (α), **Beta** (β), **Gama** (γ) and **I0** (I_0) with 10, 5, 2, 1, 0.5, 0.2 and 0.1, respectively. The default values are: Alfa=2; Beta=5; Gama=0.5; and I0=1. Then comment on the role of each parameter.

For a biological neuron network, let's define:

Item	**Meaning**
I(t)	Stimulus, **Input**
Z(t)	Avaliable Neural Transmitters inside of the Synapse, **Response**
C(t)	Avaliable Neural Transmitters outside of the Synapse
	where $\mathrm{I}(\mathrm{t}) + \mathrm{Z}(\mathrm{t}) \underset{\alpha\,(\text{come in})}{\overset{\gamma\,(\text{come out})}{\rightleftharpoons}} \mathrm{C}(\mathrm{t})$
α	Transmitter Depletion Rate (come in)
γ	Transmitter Replenishment Rate (come out)
β	β = Z(t) + C(t) = Constant
S(t)	Output Signal = I(t)Z(t), **Output**

Table 1: Def. of parameters

Then, the neuron transmitter dynamics equation can be written as:

$$\dot{Z} = \alpha\,(\beta - Z) - \gamma I Z \tag{1}$$

(1) Play with the attached program in Matlab by multiplying parameters with 10, 5, 2, 1, 0.5, 0.2 and 0.1, plot out the responses in ONE figure for each parameter, e.g., with 7 different Alfa values and all other parameters in default values.

Solution 1-1: Please see the Figure 1 to Figure 7:

(2) Similarly, find the relationship between the **overshoot** (calculate use the formula given in class, do not measure it from figure) and parameters, respectively. Plot figures of overshoot v.s. each parameter.

Solution 1-2: The equation for overshoot, A, is given by Equation 2:

$$A = \beta I_0 + \beta I_0 \frac{\alpha}{\alpha + \gamma I_0} = \frac{\gamma \beta I_0^2}{\alpha + \gamma I_0} \tag{2}$$

We can easily see that the overshoot has a linear relationship with β and $1/\alpha$, while has a

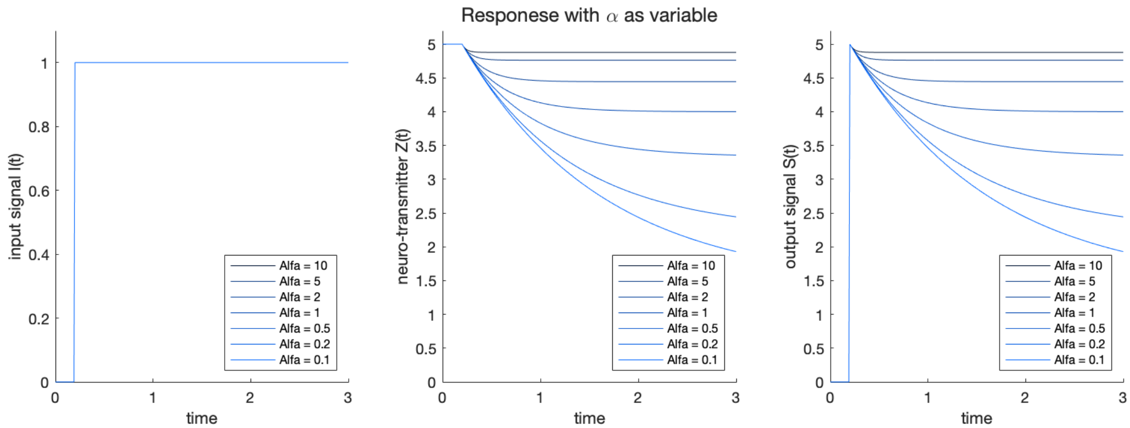


Figure 1: Plot for Question-1 Step-1, where $\beta = 5, \gamma = 0.5, I_0 = 1$

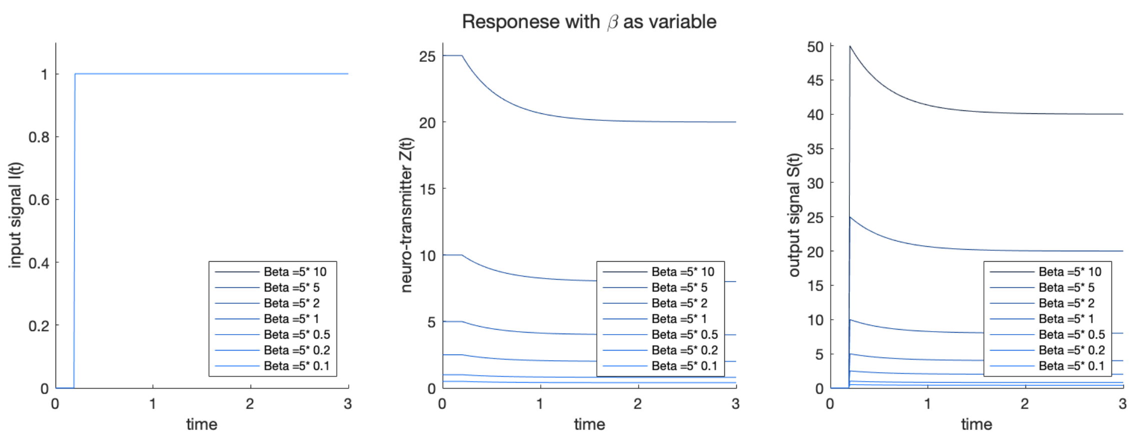


Figure 2: Plot for Question-1 Step-1, where $\alpha = 2, \gamma = 0.5, I_0 = 1$

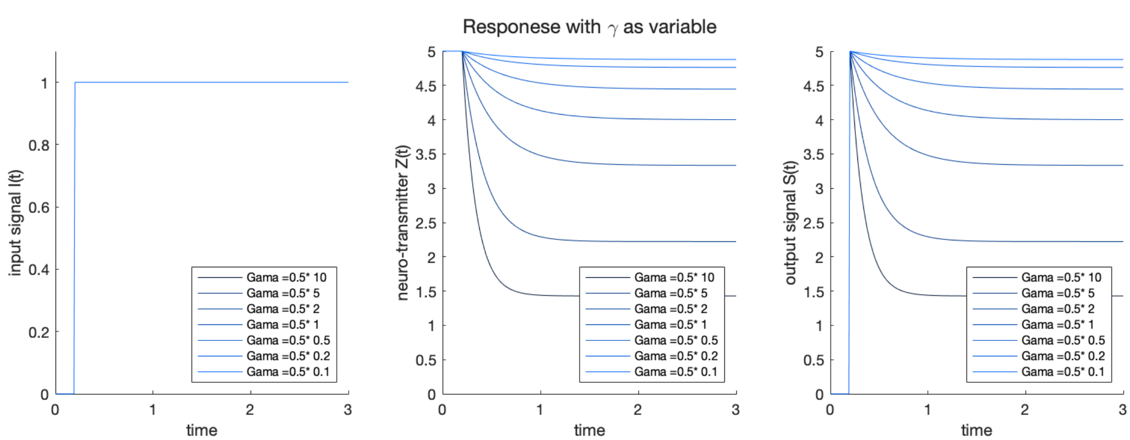


Figure 3: Plot for Question-1 Step-1, where $\alpha = 2, \beta = 5, I_0 = 1$

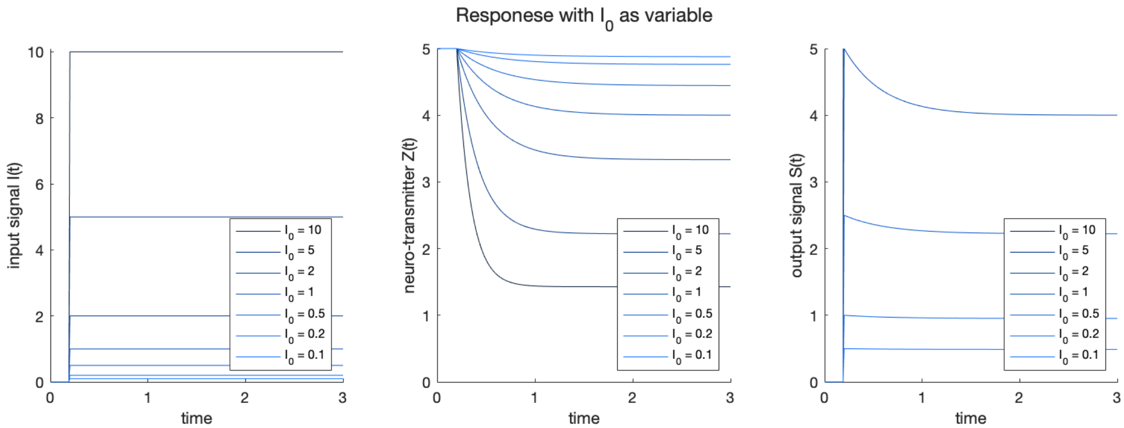


Figure 4: Plot for Question-1 Step-1, where $\alpha = 2, \beta = 5, \gamma = 0.5$

non-linear relationship with γ and I_0:

$$A \propto {}^{1}\!/_{\alpha}$$
$$A \propto \beta$$
$$A \propto \frac{C_1}{\frac{1}{\gamma} + C_2}$$
$$A \propto \frac{1}{\left(\frac{C_3}{I_0^2}\right) + \left(\frac{C_4}{I_0}\right)}$$

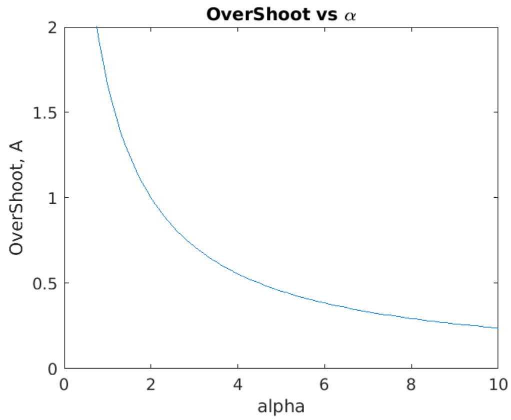
(3) Similarly, find the relationship between the time constant and parameters, respectively. Plot figures of time constant v.s. each parameter.

Solution 1-3: The equation of τ is given in Equation 3:

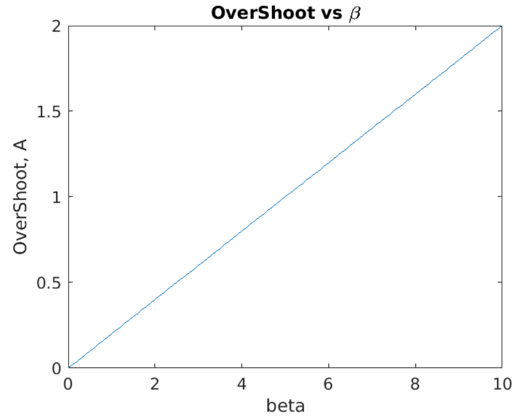
$$\tau = \frac{1}{\alpha + \gamma I} \tag{3}$$

Comments on each parameter:

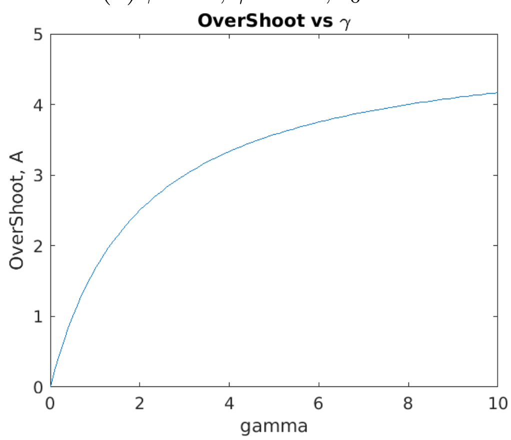
The alpha is the come in rate



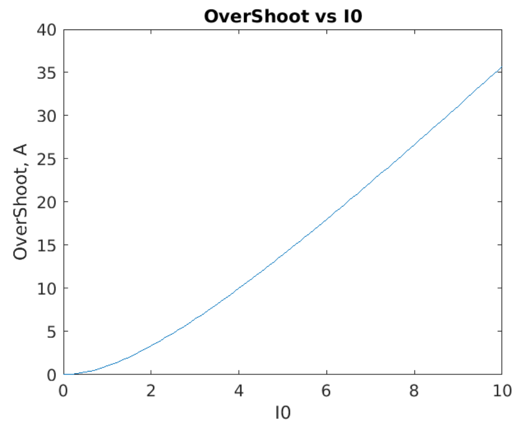
(a) $\beta = 5, \gamma = 0.5, I_0 = 1$



(b) $\alpha = 2, \gamma = 0.5, I_0 = 1$

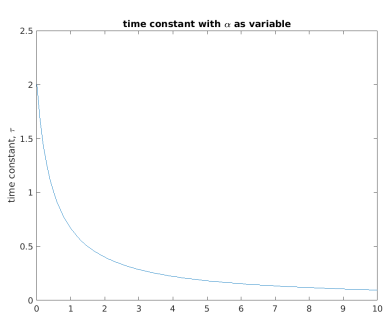


(c) $\alpha = 2, \beta = 5, I_0 = 1$

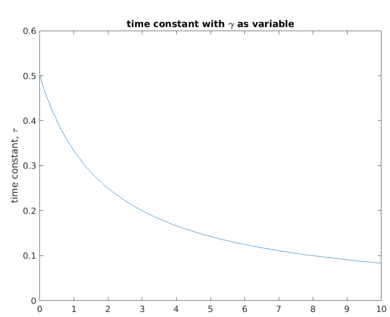


(d) $\alpha = 2, \beta = 5, \gamma = 0.5$

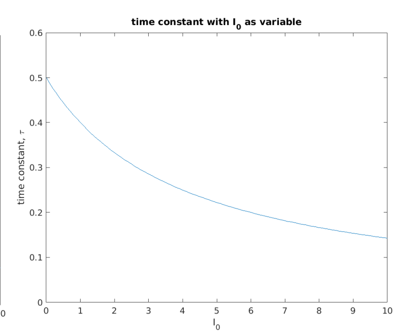
Figure 5: The graphs for Question-1 Step-2



(a) $\gamma = 0.5, I_0 = 1$



(b) $\alpha = 2, I_0 = 1$



(c) $\alpha = 2, \gamma = 0.5$

Figure 6: The graphs for Question-1 Step-3

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Question 2: Give a discussion of the parameter sensitivity of the **Shunting Model**, by multiplying **A, B, D** with 10, 5, 2, 1, 0.5, 0.2 and 0.1, respectively. The positive and negative inputs are:

$$S+ = I_{ex} \cdot u(t - t_{ex})$$

$$S- = I_{in} \cdot u(t - t_{in})$$

respectively, where constants $I_{ex} = I_{in} = 1$ are the amplitude of the inputs. Constants $t_{ex} = 0.2$ and $t_{in} = 0.8$ are the on-set time of the positive and negative inputs, respectively. Function $u(t - t_0)$ is the unit step function defined as:

$$u(t - t_0) = 1, \quad \text{if} \quad t > 0$$

$$u(t - t_0) = 0, \quad \text{otherwise}$$

The *default* values are: A=10; B=1; D=1. Then comment on the role of each parameter.

Steps:

(1) This question is similar to Question 1, except it has two inputs. By slightly modifying the program in the Appendix 1, you will get the results. The response of the shunting model with default parameter values is in Appendix 2.

(2) In the Matlab program with default parameter value, the maximum time is set as 150*0.01=1.5. However, in some case, you may need a longer time to see the response to reach its steady state.

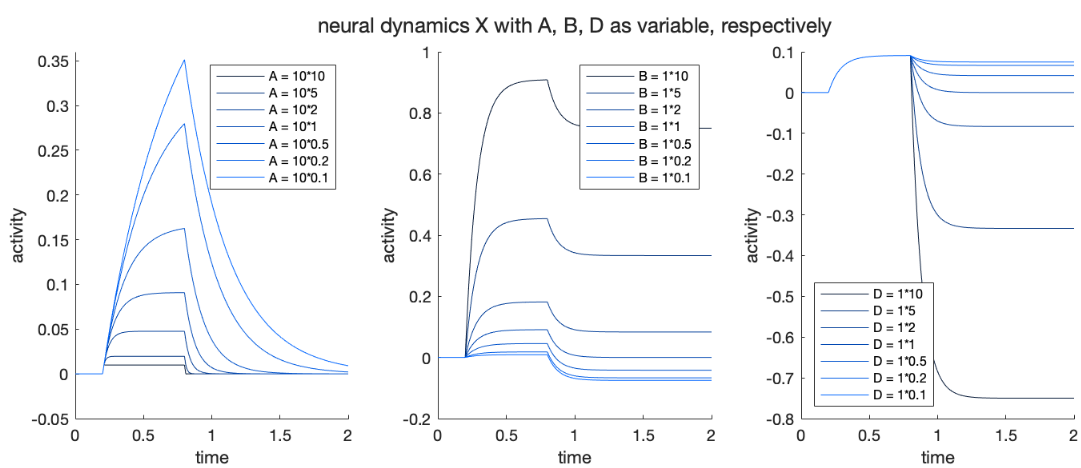

Figure 7: Plot for Question-2 Step-12