DEPARTMENT OF BIOTECHNOLOGY, IIT, MADRAS

CHENNAI – 36

BT 6270 Introduction to Computational Neuroscience

Class : Btech/MTech/MS/PhD Date : 21-1-2021

Time : 10 AM – 12 noon End-semester Examination Marks: 40

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1. One of the weaknesses of contemporary computational neuroscience that prevents it from creating good systems neuroscience models is the philosophy of:

A) Objectivism, B) reductionism, C) empiricism, D) dualism

2. The number of fixed points of the system given below,

$\dot{x} = x - y$, $\dot{y} = x^2 - 4$

A) 1, B) 2 C) 3, D) 4

3. How many limit cycles does the following system exhibit?

$\dot{r} = r(1-r^2)(4-r^2)$

$\dot{\theta} = 2 - r^2$

A) 1, B) 2, C) 3, D) 4

4. In a real. linear two-dimensional dynamical system, a "star" type of fixed point is obtained when, the eigenvalues (λ_1 and λ_2) satisfy the following condition,

A) λ_1 and λ_2 are both real and non-zero
B) λ_1 and λ_2 are complex conjugates and non-zero
C) λ_1 and λ_2 are both equal and non-zero
D) One of the eigenvalues is 0

5. An activation gate is one that:

A) OPENS with increased membrane potential
B) CLOSES with increased membrane potential
C) OPENS and CLOSES rapidly with increased membrane potential
D) CLOSES and OPENS rapidly with increased membrane potential

6. An inactivation gate is one that:

E) OPENS with increased membrane potential
F) CLOSES with increased membrane potential

G) OPENS and CLOSES rapidly with increased membrane potential
H) CLOSES and OPENS rapidly with increased membrane potential

7. The number of activation (p) and inactivation (q) gates of the Na+ channel in Hodgkin-Huxley model are:

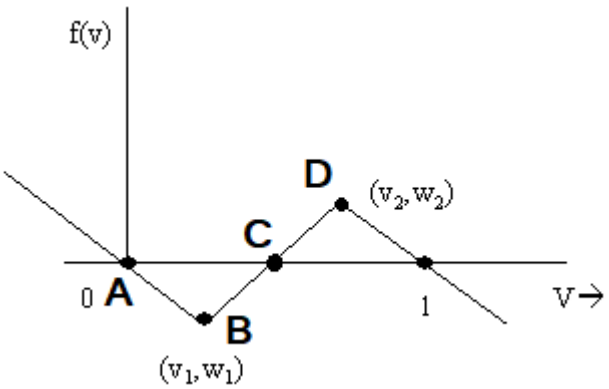
A) p = 1, q = 3, B) p=q=2, C) p = 3, q = 1, D) p = 4, q = 0.

8. The number of activation (p) and inactivation (q) gates of the K+ channel in Hodgkin-Huxley model are:

A) p = 1, q = 3, B) p=q=2, C) p = 3, q = 1), D) p = 4, q = 0.

9. Figure below shows a simplified schematic of the v-nullcline of the FitzHugh-Nagumo neuron model. Which of the marked points denotes the threshold of excitation of the neuron?

A) A, B) B, C) C, D) D



10. Which of the following sequences represents the correct sequence of events involved in neurotransmission? The list of events is given below:

    a. entry of Ca2+ ions into the presynaptic terminal
    b. opening of ion channels on the postsynaptic terminal
    c. arrival of an action potential on the presynaptic terminal

d. EPSP/IPSP
e. binding of neurotransmitter with receptors on the postsynaptic terminal
f. release of neurotransmitter

A) c,a,f,e,b,d B) b,d,c,a,e,f C) a,b,d,c,f,e D) c,f,e,a,d,b

11. If a constant current is injected into an infinite cable with uniform diameter, d, and space constant, λ, which of the following expressions denotes the voltage distribution along the length of the cable? (Note that the point of injection is taken to be the origin).

A) $V(x) = Ae^{|x|/\lambda}$, B) $V(x) = Ae^{-|x|/\lambda}$, C) $V(x) = Ae^{-|x|/\lambda}\sin(kx)$, D) $V(x) = A\coth(kx)$

12. Which of the following is the correct formula for R_∞?

A) $\frac{r_a}{\lambda}$ B) $\sqrt{\frac{r_a}{r_m}}$ C) $r_a\lambda$ D) $r_a r_m$

Given that the input resistance of a cable of finite length, L, is given by,

$$R_{in} = R_\infty \frac{R_\infty \tanh(L) + R_L}{R_L \tanh(L) + R_\infty}$$

(the following two questions are based on the above fact):

$R_\infty \tanh(L)$

13. The input resistance of the same cable with killed end boundary condition is:

A) $R_\infty \tanh(L)$, B) $R_\infty \coth(L)$, C) $R_\infty \sinh(L)$, D) $R_\infty \cosh(L)$

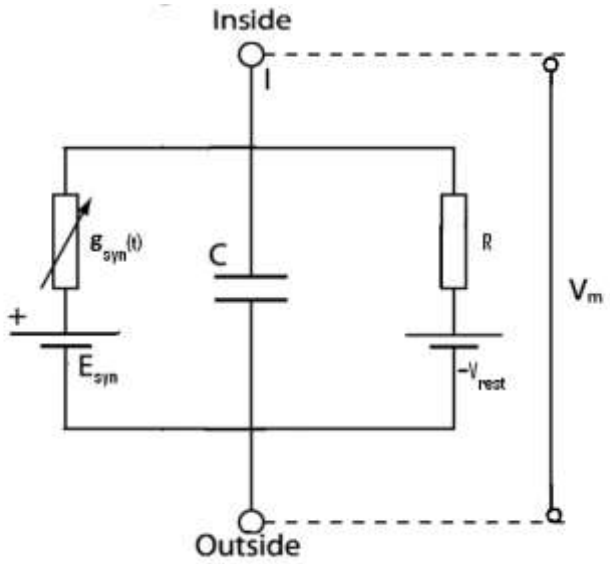
14. The input resistance of the same cable with sealed end boundary condition is:

A) $R_\infty \tanh(L)$, B) $R_\infty \coth(L)$, C) $R_\infty \sinh(L)$, D) $R_\infty \cosh(L)$

15. The conduction velocity of an unmyelinated axon varies as a function of the axon dimeter as:

A) $\sqrt{d}$, B) d, C) d^2, D) $d^{2/3}$

Figure below shows a simple circuit diagram of a fast chemical synapse. The next 2 questions are based on this figure.



16. The condition for the synapse to be an excitatory synapse is:

A) $E_{syn} > V_{rest}$ B) $E_{syn} < V_{rest}$ C) $E_{syn} > V_{rest}$ D) none of the above

17. The condition for the synapse to be an inhibitory synapse is:

A) $E_{syn} > V_{rest}$ B) $E_{syn} < V_{rest}$ C) $E_{syn} > V_{rest}$ D) none of the above

18. Shunting inhibition occurs when,

(A) When the Nernst potential of synaptic channel conductance equals resting membrane potential

(B) When synapse is inhibitory

(C) When the Nernst potential of synaptic channel conductance is much lesser than resting membrane potential

(D) When the Nernst potential of synaptic channel conductance is much greater than resting membrane potential

19. Which of the following is NOT one of the 4 components of signaling in a neuron:

(A) Dendritic processing, (B) spatio-temporal summation, (C) axon remodeling, (D) neurotransmission

Dynamics of the neuron model used in continuous Hopfield network may be described as: $\dot{u} = -u + \tanh(\lambda u)$. The following questions pertain to this neuron model:

20. The number of stable fixed points the neuron has are for $\lambda > 1$:

A) 1, B) 2, C) 3, D) 4

21. The total number of fixed points the neuron has are for $\lambda > 1$:

A) 1, B) 2, C) 3, D) 4

22. The number of stable fixed points the neuron has are for $\lambda < 1$:

A) 1, B) 2, C) 3, D) 4

23. The total number of fixed points the neuron has are for $\lambda < 1$:
A) 1, B) 2, C) 3, D) 4

24. The dynamics of quadratic-integrate-and-fire neuron is described as follows:
$\frac{dV}{dt} = V^2 + I$ Resetting mechanism: if ($V \geq V_{peak}$) V = V_{reset}.

If, I < 0 and $V_{reset} < -\sqrt{-I} < \sqrt{-I} < V_{peak}$, the dynamics of the neuron can be described as:

A) Has a single stable state which is the resting state
B) Has bistability consisting of the resting state and spiking state
C) Has bistability consisting of the resting state and limit cycle oscillations
D) Has a single stable state which is the spiking state

25. Which of the following types of dynamics can be expressed by Morris-Lecarr model?

A) Excitability and limit cycles but not bistability
B) Excitability and bistability but not limit cycles
C) Bistability and limit cycles but not excitability
D) Excitability, limit cycles and bistability

26. What is the key deficiency of the Leaky integrate and fire neuron model for spike generation?
A) There is no explicit spike in the model
B) The neuron responds only if the input current crosses a threshold
C) The firing rate grows indefinitely with increasing current
D) The firing rate saturates with increasing current

27. Consider the multilayer perceptron defined as y = g(w1*V1 + w2*V2 – b); V1 = g(w11*x1 + w12*x2 – b1); V2 = g(w21*x1 + w22*x2 – b2), where x1 and x2 are inputs and y is the output. For which of the following weight patterns does the network simulate an EXOR gate? (g() = step function).
(A)w11 = w12 = 1; b1 = 0.4; w21 = w22 = 1; b2 = 1.6; w1 = 1 =-w2; b = 0.1.
(B)w11 = w12 = -1; b1 = 0.4; w21 = w22 = 1; b2 = -1.6; w1 = -1 =w2; b = 0.1.
(C)w11 = w12 = 1; b1 = -0.4; w21 = w22 = -1; b2 = 1.6; w1 = -1 =-w2; b = 0.1.
(A)w11 = w12 = 1; b1 = 0.6; w21 = w22 = 1; b2 = 1.4 ; w1 = 1 =-w2; b = 0.9.

28. Which of the following is NOT a merit of a multilayer perceptron?
(A) Local minima, (B) parallelizable training, (C) universal approximation, (D) non-unique solutions

29. In a Hopfield network, a spin-glass state is:
A) A state that has high correlation to any of the stored patterns
B) A state obtained by performing a spin on all the bits of a stored pattern

C) A state that has low correlation to any of the stored patterns

D) A state that can be expressed as a linear combination of any two stored patterns

30. In a discrete Hopfield network, if two states S1 and S2 are stable,

A) S1+S2 is also stable

B) S1-S2 is also stable

C) –S1 and –S2 are stable concept of mirror states (spurious states)

D) Min(S1, S2) is stable

The following questions are from (Kell and McDermott 2019):

1) Deep neural networks as models of perceptual systems are known to attain human-level performance in which of the following tasks?

A) Object Recognition

B) Speech Recognition

C) Handwriting generation

D) All of the above

2. In a typical deep convolutional neural network the operation that enables units in the later layers gain access to a greater proportion of the stimulus is ?

A) Receptive Field

B) Relu Activation

C) Maxpooling

D) Gradient Descent

3. The gap between Artificial neural networks and Human sensory systems can be reduced to some extent by incorporating the following minor modification to standard Deep neural network architectures.

A) Biological Learning

B) Recurrent connections to feedforward networks

C) Enhanced backpropogation algorithms

D) Action potentials and Neuromodulators

4) Downsampling operations without the constraint of preceding low pass filter leads to

A) Aliasing

B) Bad classification

C) Optimization

D) Efficient processing

5) Stimuli generated by Gradients of output units of a network with respect to its input to generate small perturbations to an input signal that cause it to be misclassified is known as

A) Cumulative Stimuli

B) Adversarial Stimuli

C) Gradient Stimuli

D) Effective Stimuli

6) At present,it is easily possible to generate adversarial stimuli for a human perceptual system

A) TRUE

B) FALSE

7) The 'feature similarity gain' model of Visual attention proposes the following:

A) Attention scales a neuron's activity inversely proportional to its preference for the attended stimuli

B) Attention scales a neuron's activity proportional to its preference for the attended stimuli

C) Attention has no impact on the neural activity

D) None of the above

8) In a DNN trained to recognize spoken words and musical genres, the frequency spectrum of a sound was best estimated from the

A) Early Layers

B) Intermediate Layers

C) Deep Layers

D) All of the above

9) Neural predictions from very high-performing networks have plateaued or even declined in accuracy, as if the networks have begun to diverge from biologically relevant solutions. This divergence could reflect differences between the specific tasks used to optimize current DNNs and those that may have constrained biological systems over the course of evolution and development.

A) True

B) False

10) The example given in the paper where a retinal receptor lattice used for a simple visual search task illustrates

A) How task constraints shape behavior and the brain

B) Saccadic eye movements shift the image across retina

C) Division of auditory cortex into at least two stages

D) Actions like zooming is present in rimate visual system