UNIVERSITY OF BRISTOL

Sample 2022 Examination Period

FACULTY OF ENGINEERING

M Level Examination for the Degree of
Master of Engineering / Masters of Science

COMSM0094-J
Learing, Computation and the Brain

TIME ALLOWED:
2 hours

Answers to COMSM0094-J: Learing, Computation and the Brain

Intended Learning Outcomes:

Multiple choice questions.

These questions have one correct answer, please pick A, B, C or D.

Q1. Neurotransmitter are found in the

    A soma

    B chemical synapses

    C electrical synapses

    D glial cells

Q2. ionotropic and metabotropic are examples of

    A neurotransmiters

    B neuromodulators

    C receptors

    D neurons

Q3. Damage to Werknike's area causes

    A expressive aphasia

    B fluent aphasia

    C episodic ataxia

    D spinocebellar ataxia

Q4. Parkinson's disease is associated with cell death in

    A the frontal lobe

    B the hippocampus

    C the basal ganglia

    D the amygdala

Q5. Purkinje cells are found in

    A the cerebellar cortex

    B the cerebellar nucleus

    C the frontal cortex

    D the hippocampus

Solution: A - the cerebellar cortex

Q6. Which line of code is correct Python

    A `a<-[1,2,3]`

    B `a=[1,2,3]`

    C `a<-Vector{1,2,3}`

    D `a=Vector{1,2,3}`

> **Solution:** B

Q7. In the integrate and fire equation

$$\tau\frac{dV}{dt} = E_l - V + R_m I_e$$

the constant R_m has the units of

    A voltage

    B resistance

    C time

    D conductance

> **Solution:** B - resistance

Q8. When modelling neurons, where does the most important nonlinearity arise?

    A somatic spikes

    B synaptic transmission

    C axonal transmission

    D dendritic spikes

> **Solution:** A - somatic spikes.

Q9. For a Hopfield network with symmetric weights there exist

    A false wells

    B stable states

    C fluctuations in the energy landscape

    D peaks of attraction

Q10. What cell type might we describe using difference-of-Gaussians tuning curve?

    A retinal ganglion cell

    B V1 simple cell

    C V1 complex cell

    D V4 cell

Short answer questions

These question expect an answer that is a number, or a few words, no marks will be given for workings.

Q1. What is the value of f for differential equation

$$\tau \frac{df}{dt} = a - f$$

at time $t = 1$ if $f(0) = 1.0$ where $\tau = 0.25$ and $a = 2.0$. You can write your answer in terms of the exponential.

Solution: f=2-exp(-4)

Q2. What are the steady-state values of the differential equation

$$dy/dt = -\sin y$$

Solution: $y = n\pi$

Q3. Give a typical value of the resting potential of a neuron.

Solution: any value from -80 to -65 mV would do

Q4. The flow of which ions are described in the original Hodgkin-Huxley equation?

Solution: sodium and potassium

Q5. What function is typically attributed to the dentate gyrus

> **Solution:** pattern seperation

Q6. In the Taylor expansion of $f(x) = \exp x$ around $x = 0$ we have $f(x) = 1 + x + ax^2 + ...$ What is the value of a?

> **Solution:** 0.5

Q7. Consider the delta rule, where we initially have $w = (0, 1)$. We then do TWO delta-rule updates, with $x = (1, -1)$, a target of $y^* = 2$, and a learning rate of $\nu = 0.2$. What are the final weights?

> **Solution:** $w = (0.96, 0.04)$

Q8. Name two unusual features of cerebellar Purkinje cells

Solution: complex spikes, two types of spiking, large

Q9. Name the process in which two Gaussians are combined to produce a Bayes optimial estimate.

Solution: Bayesian fusion.

Q10. One percent of pound coins are fake, ninety percent of fake coins melt, the melting device has a fluctuating temperature which means eight percent of real coins also melt. If a coin melts what is probability it was fake.

Solution: 0.1

Long answer questions

These questions expect an answer that is two to four lines long.

Q1. What is meant by saying the Integrate and Fire neuron is non-linear, what about the Hodgkin and Huxley model?

Solution: The Integrate and Fire solution is non-linear because of the reset; if you have two solutions to the model and add them, the sum is not also a solution because it will not reset at the threshold. The Hodgkin and Huxley equation is also non-linear, the complex activation functions for the voltage gated channels mean the sum of two solutions will not also be a solution.

Q2. Write a short programme in Python, MATLAB or Julia that will perform Euler integration for the equation $df/dt = a - f$.

Solution: I won't write this out here but the important thing is to have a loop over time and an update `f=f+(a-f)*delta` where `delta` is the time increment.

Q3. Describe the Ernst and Banks experiment.

Solution: The Ernst and Banks experiment asks participants to decide which of two cuboids is taller; participants are able to see the cube and they able to feel them, though in each case the sensory information is fictive, they are seeing a picture and the tactile sensation is produced by a manipulandum. The sensory information can have noise added to it and there are vision only, touch only and touch and vision together conditions. This is used to assess Bayesian fusion.

Q4. Which experimental stimulus might a V1 simple cell respond most strongly to?

Solution: The V1 cells respond to edges, so a V1 simple cell would respond most strongly to a short line segment in its preferred location and in its preferred orientation.

Q5. How might Kalman filtering describe cerebellar control of movement.

(cont.)

Solution: The brain receives multiple clues as the position of our limbs from vision and from proprioception, for example, the flex sensors in the joints. In a Kalman filter view of the cerebellum this information is supplemented with predictions about the limb postion based on the motor signals sent to the limb.

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