

EE434
Biomedical Signal Processing
Spring 2011
Final

Due date: June 10th, 2011, midnight

Instructions: This is a take-home test. Complete the questions, and return your work as a single PDF document by e-mail before the due date and time. Clearly explain your methodology and justify your answers. Sharing of ideas is encouraged, but sharing of results and/or text is not. Your name on your test is a testimony that you have neither received nor given any unauthorized assistance. Correct answers to wrong questions are not creditable.

Question 1: (15 pts) Consider the Hodgkin-Huxley action potential model, and explain how the following changes would affect the action potentials generated by an external current.

- a) (5 pts) Half of the Na⁺ channels on the axonal membrane are inhibited.
- b) (5 pts) Half of the K⁺ channels on the axonal membrane are inhibited.
- d) (5 pts) The axon has been placed in a lower Na⁺ environment.

Question 2: (25 pts) Stochastic models of molecular evolution on nucleotide sequences characterize the probability of replacing a base X at a site with another base Y in t units of time by a matrix $P(t)$ of probabilities $P_{X \rightarrow Y}(t)$ determined by

$$P(t) = \begin{bmatrix} P_{A \rightarrow A}(t) & P_{A \rightarrow G}(t) & P_{A \rightarrow T}(t) & P_{A \rightarrow C}(t) \\ P_{G \rightarrow A}(t) & P_{G \rightarrow G}(t) & P_{G \rightarrow T}(t) & P_{G \rightarrow C}(t) \\ P_{T \rightarrow A}(t) & P_{T \rightarrow G}(t) & P_{T \rightarrow T}(t) & P_{T \rightarrow C}(t) \\ P_{C \rightarrow A}(t) & P_{C \rightarrow G}(t) & P_{C \rightarrow T}(t) & P_{C \rightarrow C}(t) \end{bmatrix} = \exp(Qt)$$

where Q is the associated rate matrix. The rate matrix presumed by the Kimura's two-parameter model is given by

$$Q = \begin{bmatrix} -\alpha - 2\beta & \alpha & \beta & \beta \\ \alpha & -\alpha - 2\beta & \beta & \beta \\ \beta & \beta & -\alpha - 2\beta & \alpha \\ \beta & \beta & \alpha & -\alpha - 2\beta \end{bmatrix}$$

where α and β are the transition and the transversion rates respectively.

- a) (10 pts) Compute and plot the curves of $P_{A \rightarrow G}(t)$, $P_{C \rightarrow A}(t)$, and $P_{T \rightarrow T}(t)$ using $\alpha = 1.0$ and $\beta = 0.5$ for $t \in [0, 1]$.
- b) (10 pts) Repeat above using $\alpha = 2.0$ and $\beta = 1.0$.
- c) (5 pts) What can you say about the limit values and the speed of convergence of $P(t)$ as t goes to infinity between the two cases above?

Question 3: (30 pts) Carry out a SAM analysis on the dataset GDS3542 available for download at the GEO data server, and identify the differentially expressed genes between

- a) (10 pts) the baseline and at 12 hours.

Multiple Choice Biomedical Signal Processing Final Exam

Richard Bailey



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