MATLAB Homework 02

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Codes location:
https://github.com/yifuhhh/EE385J_Biomed_Image/tree/master/HW02/Submission

1. **(25 pts) We have two mice that were imaged with ^{18}F-MISO PET. ^{18}F-MISO is a PET tracer (i.e. contrast agent) that accumulates (and is retained) in hypoxic cells. Mice with HER2+ breast cancer received injections of either saline (control group) or trastuzumab (treated group). Tratsuzumab primarily inhibits cell proliferation, however, it also has been known to suppress angiogenesis. Tumors tend to overexpress angiogenetic factors resulting in abnormal vasculature (poor perfusion and delivery, leaky). Suppressing angiogenic factors results in the "normalization" of tumor vasculature and potentially improving tissue perfusion.**
   a. How is tumor hypoxia related to tumor vasculature?

      The relationship between tumor hypoxia and tumor vasculature is the inability of the tumor's vascular network to sustain nonmonic conditions for the rapidly growing tumor. Some portions of the tumor do not have the necessary vessel network to supply sustainable amount of oxygen.

   b. (2 Plots) Calculate the SUV in muscle at each time point for the control and treated mouse.
      i. (1st plot) Plot the mean and 95% confidence interval.

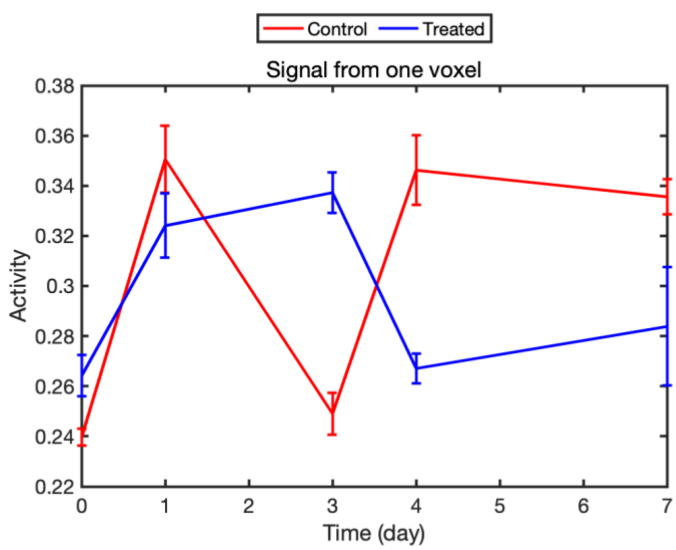


Figure 1. Mean and 95% confidence interval of muscle SUV.

      ii. (2nd plot) Plot the mean and 95% confidence interval normalize the means to day 0's value.

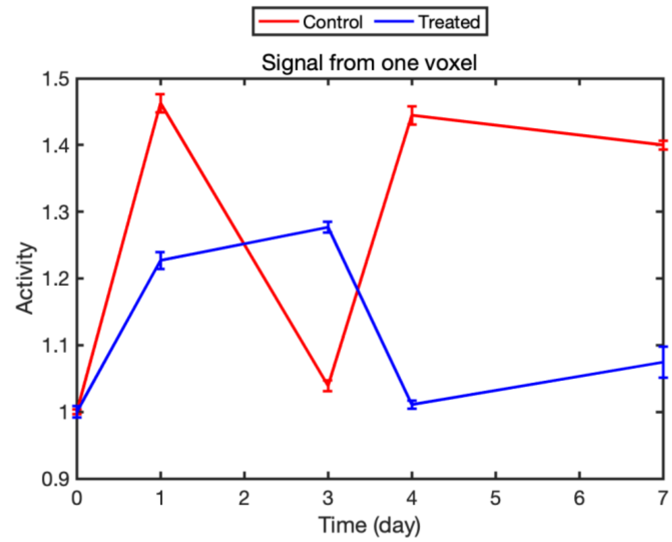


Figure 2. Mean and 95% confidence interval of muscle SUV, normalized.

c. (2 Plots) Calculate the SUV in tumor at each time point for the control and treated mouse.

   i. (1st plot) Plot the mean and 95% confidence interval.

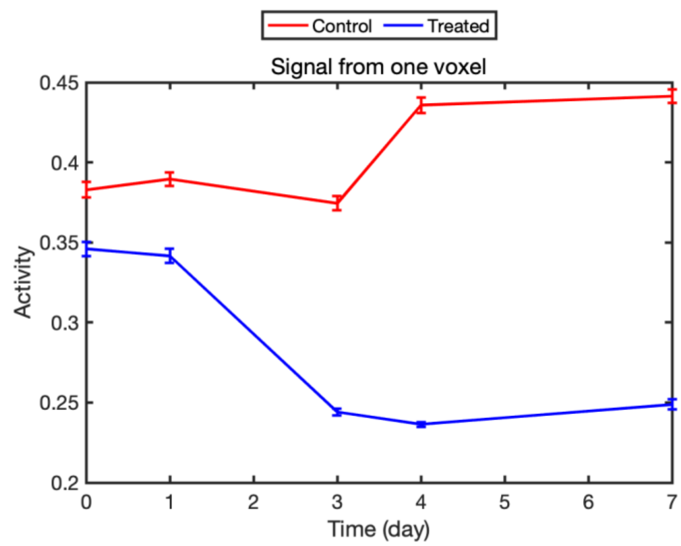


Figure 3. Mean and 95% confidence interval of tumor SUV.

   ii. (2nd plot) Plot the mean and 95% confidence interval. Normalize the means to day 0's value.

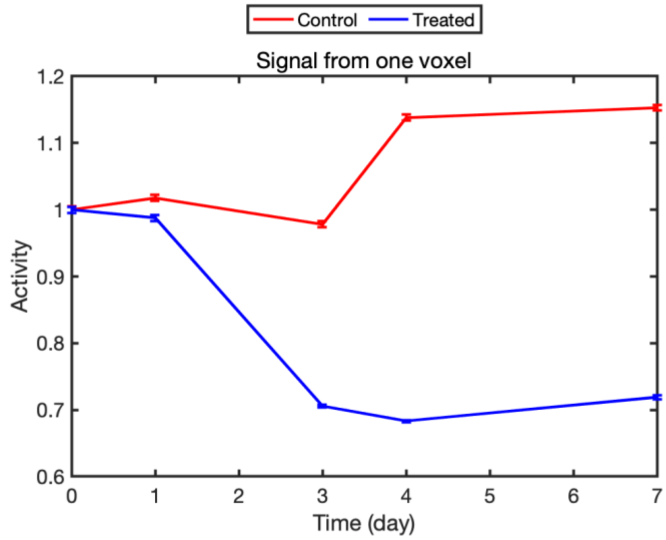
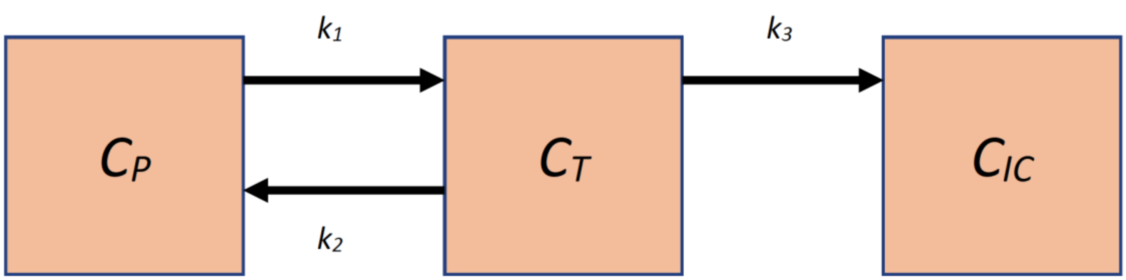


Figure 4. Mean and 95% confidence interval of tumor SUV, normalized.

d. What does the SUV tell us about the mice (or the drug they are receiving)? Based off of these two mice, do these imaging measures support our hypothesis on what Tratsuzumab is doing to the tumor?

The SUV tells us that the drug is effective on tumor and does not have obvious effect on muscle cells. The imaging measures support the hypothesis.

2. **(25 pts) PET kinetic modeling & curve fitting: Expand the ODE45/curvefit code we developed in class to estimate model parameters from this digital reference object (DRO). DROs are used to evaluate the new code and to test out image acquisition settings.**



$$\frac{dC_P}{dt} = -k_1 C_P(t) + k_2 C_T(t)$$

$$\frac{dC_T}{dt} = k_1 C_P(t) - k_2 C_T(t) - k_3 C_T(t)$$

$$\frac{dC_{IC}}{dt} = k_3 C_T(t)$$

a. DRO1 is a 4D (2 in space, 2 in time) array where model parameters (k1, k2, and k3) are varied spatially (in x-y plane) throughout the domain. DRO(y, x, :, 1) = the [CT] time course, DRO (y, x, :, 2) = the [CIC] time course for position (y, x). Extend the code from class to fit each k1, k2, and k3 at each location. Use the imagesc command to display the estimated k1, k2, and k3. Label your plots, an add colorbars.

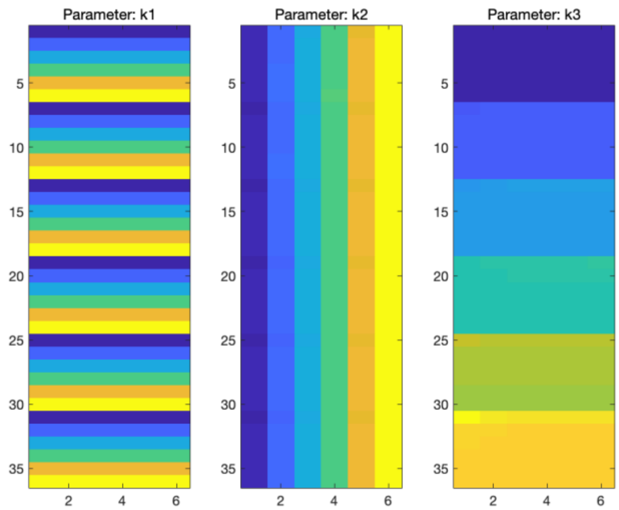


Figure 5. Estimated k_1, k_2 and k_3.

b. DRO2 consists of 3 different concentration time courses collected with different SNRs. Extend the code from class to fit for k_1, k_2, and k_3 from each time course. What is the effect on SNR on parameter estimates? Calculate the percent error between the estimated and true parameters for each SNR scenario (Assume $k_1 = 0.1$, $k_2 = 0.2$, and $k_3 = 0.05$). Provide 3 plots of the model fit (use lines) plotted with the measurement (use dots).

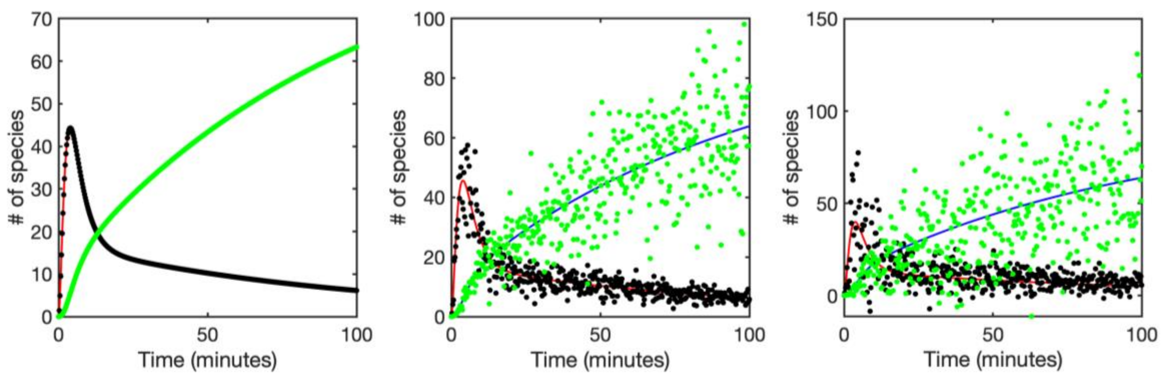


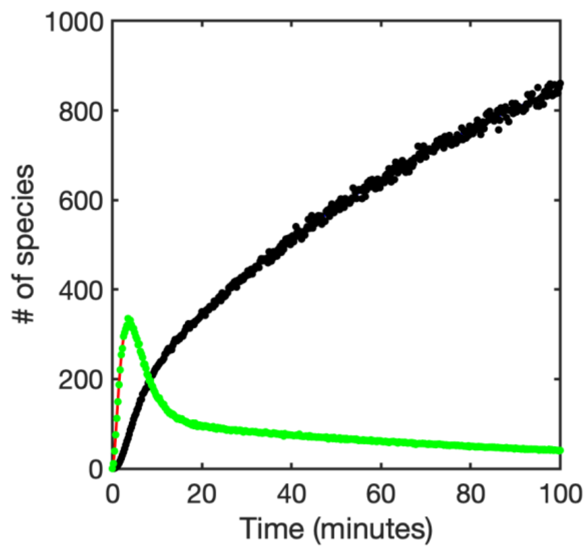
Figure 6. Plots of the models fit with the measurements under different noise level.

	Error		
	k1	**k2**	**k3**
No noise	-0.0035	0.00056	0.0029
Medium	0.045	0.0410	-0.0060
High	-0.0252	0.1777	0.2215

Table 1. The error of each parameter in DRO2.

SNR will affect the precision when estimating the parameters k1 – k3. The higher SNR is, the larger the error will be.

c. DRO3 consist of 1 set of concentration time courses (DRO3(:, 1) = [C_T] time course, DRO3(:, 2) = [C_P] time course). Sample DRO3 using the following commands:
DRO3_high_tr = DRO3(:, :);
DRO3_medium_tr = DRO3(1 : 10 : end, :);
DRO3_low_tr = DRO3(1 : 40 : end, :);
Extend the code from class to fit for k_1, k_2, and k_3. How does temporal resolution effect our ability to estimate model parameters? Calculate the percent error between the estimated and true parameters for each SNR scenario (Assume $k_1 = .8$, $k_2 = .2$, and $k_3 = 0.1$). Provide 3 plots of the model fit (use lines) plotted with the measurement (use dots).



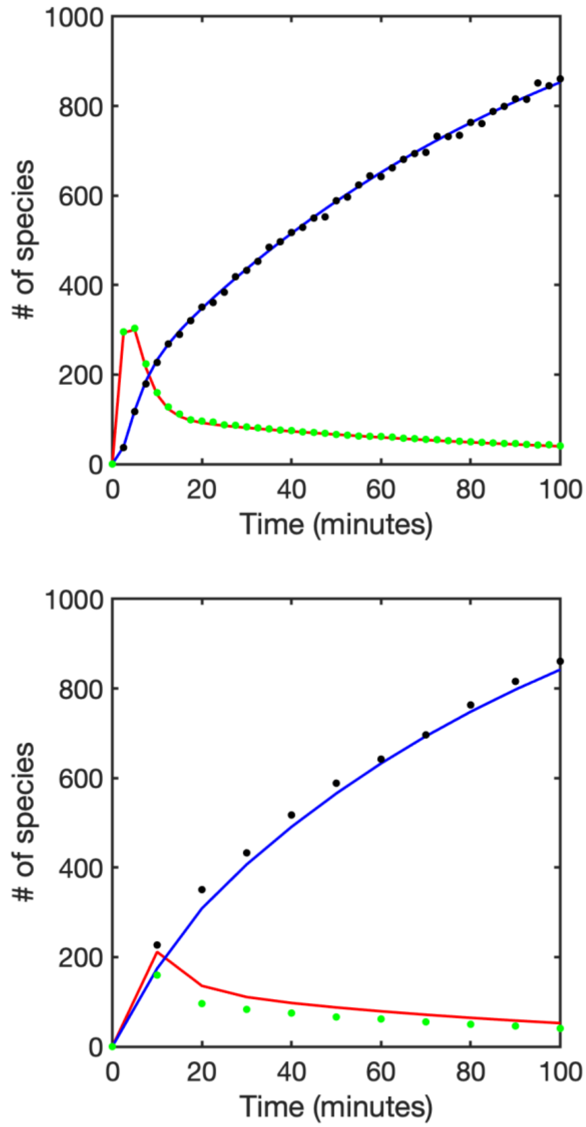


Figure 7. Plots of the models fit with the measurements under different temporal resolution.

	Error		
	k1	**k2**	**k3**
High TR	0.0060	0.0123	0.0042
Medium TR	0.0228	0.0543	0.0289
Low TR	-0.3549	-0.6292	-0.1901

Table 2. The error of each parameter in DRO3.

Temporal resolution will affect the precision when estimating the parameters k1 – k3. The higher the temporal resolution is, the smaller the error will be.