ST 495 Advanced computing for statistical methods
Homework problem set 2

January 24, 2022

No `R` packages are permitted for use in this assignment.

1. Using the real data set that you have found as part of Homework 1, to be used for your midterm project, propose a statistical model with population features that may be appropriate to estimate from your data. For example, if your data set includes housing prices in US along with a variety of other housing related covariates, then you might be interested in learning regression parameters for explaining the variation in housing prices. Specifically, if Y denotes the price of a given house, X_1 is the square footage of the house, X_2 is the city where the house is located, etc., then perhaps you could formulate the linear model
$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + U,$$
where U is a random error variable, and $\beta_0, \beta_1, \beta_2, \ldots$ are the coefficient parameters (i.e., the population features) that you will estimate with your real data. Note that your statistical model need not be a linear model; this is simply an example for illustration.

2. Let $M \in \mathbb{R}^{p \times p}$ and $b \in \mathbb{R}^p$. Then for any solution $x \in \mathbb{R}^p$, the system of linear equations
$$Mx = b$$
is said to be in *row echelon form* if the matrix M is upper triangular. Recall from your linear algebra prerequisite course a system of linear equations can always be re-expressed in row echelon form via a series of row operations. Write a function in `R` that takes as input `( M, b)` where `M` is a $p \times p$ matrix and `b` is a p-dimensional column vector and returns the row echelon form of the arguments `M` and `b`. This can be done via the Gaussian elimination algorithm (`https://en.wikipedia.org/wiki/Gaussian_elimination`).

3. Write an algorithm to solve for at least one solution to a row echelon form expression of a system of linear equations (if a solution exists). More specifically, assume you begin

as in question 2 with an arbitrary system $Mx = b$. Then passing this system through the function that you wrote for question 2 will produce the row echelon form of the system, $\widetilde{M}x = \widetilde{b}$. Your function for this question will be able to solve for at least one solution (if a solution exists) to the system $\widetilde{M}x = \widetilde{b}$, which you know is in row echelon form. This can be done via the back substitution algorithm (`https://en.wikipedia.org/wiki/Triangular_matrix#Forward_and_back_substitution`)

4. Use the function you wrote for question 3 to finish writing the function in lecture_code_2.r for determining an eigenvector associated with an eigenvalue of a given triangular matrix $A \in \mathbb{R}^{p \times p}$. Your function should take as an input `( A, lambda)`, where `lambda` is a user-supplied eigenvalue of A, and return an eigenvector associated with `lambda`.