Applied Computing (CS–4015)
Final Exam

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1. Optimization (30 points)
   Consider the following function:

$$f(\mathbf{x}) = \sum_{i=1}^{6} \sin(x_i)\ \sin^{18}\left(\frac{i x_i^2}{\pi}\right) \tag{1}$$

   where $0 \leq x_i \leq 5$.

   Maximize function $f(\mathbf{x})$ using the Nelder-Mead algorithm (`fminsearch`) and simulated annealing (`simulannealbnd`). Modify whatever parameters you deem necessary to produce a good performance of these algorithms, regardless of the state of the random number generator. Use randomly generated initial point in the valid range of $\mathbf{x}$.

   a) Implement $f(\mathbf{x})$ as a MATLAB function.

   b) Give your best solution found (optimal $\mathbf{x}$ and evaluation of $\mathbf{x}$) for each algorithm.

   c) Which of these two algorithms has a better expected performance on this problem when varying the initial point(s)? Justify your answer.

2. Integer programming (20 points)
   An airline company is considering the purchase of new long-, medium-, and short-range jet passenger airplanes. The purchase price is \$33.5M for each long-range plane, \$25M for each medium-range plane, and \$17.5M for each short-range plane. The board of directors has authorized a maximum of \$750M for these purchases. Regardless of which planes are purchased, air travel of all distances is expected to be sufficiently large enough so that these planes would be utilized at essentially maximum capacity. It is estimated that the net annual profit (after subtracting capital recovery costs) would be \$2.1M per long-range plane, \$1.5M per medium-range plane, and \$1.15M per short-range plane.

   Enough trained pilots are available to the company to crew 30 new airplanes. If only short-range planes were purchased, facilities would be able to handle 40 new planes. However, each medium-plane is equivalent to $1\frac{1}{3}$ short-range planes, and each long-range plane is equivalent to $1\frac{2}{3}$ short-range planes in terms of their use of maintenance facilities.

   Using the preceding data, management wishes to know how many planes of each type should be purchased to maximize profit.

   a) Formulate the problem as an integer programming problem.

   b) Use `intlinprog` to find the solution (number of planes of each type and maximum profit).

3. Learning (50 points)
   The age of a specific species of shellfish is related to several physical characteristics. The sheet `data` of the Excel file `shellfish.xlsx` contains data of 4077 individuals, and their ages.

   a) Train a neural network using the information of these 4077.

      1) This data must be divided into training, testing, and possibly validation examples. Explain your decision when choosing these data sets.
      2) Explain any pre-processing done to the data.

   b) Using your trained neural network, determine the age of the 100 individuals in sheet `predict`. Write the results to as a column of an Excel worksheet.

   c) Give an estimate of the expected error of your neural network on new data. Explain your answer.

Zip file

You should upload to Blackboard a zip file containing the following:

1. A MATLAB script that can reproduce all your experimental results. This script should start with the command `rng(31416)`, and should not contain any other call that initializes the state of the random number generator. This script must have you name(s) and student number(s). The script file should contain the following text as a comment:

   > *In submitting the solution to this final exam, I (we)* ⟨your name(s)⟩ *affirm my (our) awareness of the standards of the Tecnológico de Monterrey Ethics Code.*

2. All the function files that you programmed and that are needed to run the previous script.
3. The `.html` folder that results of *publishing* the previous script.
4. A `.pdf` file of the result of printing the *published* script.
5. The `.mat` file containing your trained neural network for problem 3.
6. The Excel file containing the age for the individuals in the sheet `predict`.