MATH 2121 **Mathematical Modeling and Simulation** **Spring 2025**

Problem Set 3

(Out Tue 02/04/2025, Due Tue 02/18/2025)

Submissions are to be done by sending an email with subject `MATH 2121: Problem set 3` to the course instructor, containing: all requested Matlab files (called `yourfamilyname_problem3X.m`), plus a single file (PDF preferred), called `yourfamilyname_pset3.pdf`, that contains all requested explanations.

Problem 3

Modify the Matlab file `temple_abm_butterfly_animation.m` from the course website `http://faculty.cst.temple.edu/~seibold/teaching/2025_2121/` so that the butterflies affect the background field, in the following fashion.

(a) The field `F`, which initially is the elevation field, is modified by each butterfly so that at each step of its random walk, the butterfly lowers the value of `F` at its current location by 1. This could be interpreted as pheromones that are repellent to other agents. [Hint: you must change the line `nf = f(X(end,1)+rx,X(end,2)+ry);`, which uses the function `f`, so that instead the 2D array `F` is used, e.g., via the command `nf = F(sub2ind(size(F),X(end,2)+1+ry,X(end,1)+1+rx));`.] Change the code so that at the beginning of each butterfly run the field `F` is plotted anew (also display a colorbar), and each butterfly's path is plotted at once in the end of the random walk. Let the program run for 1000 butterflies. Submit your new program under the filename `yourfamilyname_problem3a.m` .

(b) Compare your above program against the following two modifications of it: first, instead of butterflies lowering the value of `F` at their location, have them *increase* the value of `F` by 1 (modeling attractive pheromones). Second, serving as a reference, have the butterflies leave `F` unaffected (i.e., the original model). Run each of the three models/simulations for 1000 butterflies and report/explain the qualitative differences in the behavior you observe (both within each model over the course of many butterflies, as well as across different models).

(c) Augment your above program(s) so that for each butterfly it stores the distance (as the crow flies) between the start point and the end point of the butterfly's path. Then have the program, after 1000 butterflies have been simulated, output (i) the histogram of distances for the first 500 butterflies, and (ii) the histogram of distances for the last 500 butterflies. Produce these two histograms for each of the three versions of the simulation from part (b), i.e., butterflies lower the field `F`, butterflies raise the field `F`, and butterflies leave `F` unaffected. Submit your program that produces the 6 histograms under the filename `yourfamilyname_problem3c.m` , and explain your observations.