MATH 2121 **Mathematical Modeling and Simulation** **Spring 2024**

Problem Set 1

(Out Thu 01/18/2024, Due Tue 01/30/2024)

Submissions are to be done by emailing to the course instructor: all requested Matlab files, plus a single file (PDF preferred) that contains all requested explanations.

Problem 1

Download and run the Matlab file `temple_abm_mexican_wave.m` from the course website
`http://math.temple.edu/~seibold/teaching/2024_2121/`

(a) Explain why a "wave" arises that travels to the right.

(b) Modify the model so that it is possible to have waves traveling to the left and waves traveling to the right. [Hint: You may consider allowing more states than just 0="sitting" and 1="standing".] Prescribe an initial state that produces one wave traveling to the left and one wave traveling to the right. Submit your new program under the filename `yourfamilyname_problem1b.m`
Describe what happens when the two waves collide, and explain (based on your model) why this happens.

(c) In reality, a wave created by the spectators in a stadium is several people wide. Modify the model so that waves arise that are at least 5 agents wide (i.e., at any time, at least 5 adjacent agents are not sitting down). [Note: You are allowed to introduce agent–agent interactions that are non-local in the sense that an agent uses information from further away that its immediate neighbors only.] Submit your new program under the filename `yourfamilyname_problem1c.m`

(d) Humans are not executing their motions perfectly; there is always some noise in their actions. Nevertheless, Mexican waves tend to travel in a stable fashion, despite the fact that not every spectator behaves "correctly" with regards to transmitting the wave. In mathematical terms, one can say that the wave is "robust", or "stable", with regards to small perturbations. Now modify/expand your previous model (ideally, one that produces waves that are multiple agents wide) to allow for a random component in the agents' behavior. Decide what type of randomness you perceive as realistic (look at videos of spectator waves on the internet). Write up a brief description of your model, and argue why you think it is realistic. Submit your new program under the filename `yourfamilyname_problem1d.m`
Whatever you come up with, your model should produce the following behavior: (i) a visible noise on the level of the individual agents; but (ii) a wave that travels in a reasonably stable fashion, despite the noise. [Hint: Equipping the agents with non-local information is probably a good idea, as this would allow for a mechanism to average out the noise.]