Midterm 02 Bio hazard spread problem (100 points)

- One report per team is enough, but make sure everyone is listed in the authors list.
- Discuss the relevant physics equations, describe your solution, show results. Report page limit is 10 pages excluding listings which should be in appendixes, font size to be no less than 12pt. The emailed submission must have all relevant listings in the attachments.

Imagine that aliens are invading the Earth. Your team's job is to organize the most productive resistance (i.e. the one which generates the most counter alien equipment for a given number of days). You spread your team members randomly and uniformly across the available area (with only 1 person per cell).

The aliens do not care about the Geneva convention and actively use bio weapons. On the zero day (and only this day), aliens were able to infect 200 people (or all of your group if its size is less then 200 people) at random places with a virus. Luckily, it happens only once. However, every day aliens bomb the planet with bio bombs, which results in 0.006 probability to get infected with the same virus in that day for every human. The virus has following properties

- the probability to transfer the virus to a next cell neighbor in all 4 directions (up, down, left, and right) is the same and equals to 0.16 per interaction
- probability of dying from this virus is .04 per turn/day
- there is no cure for this virus
- virus cannot jump to an empty (unpopulated) cell

We will make a reasonably simple model of the virus spread and the production of counter-alien equipment.

You are in charge of the square territory of 100×100 cells. Each cell might have a human or be empty. At the beginning of each day all alive members generate 1 unit of the counter-alien equipment per capita (it does not matter if a person is ill or healthy). Then they talk to the next cell neighbors to exchange the news and updated blueprints (radio is jammed by aliens) in the four directions (north, south, west and east). Notice that each neighbor speaks or interacts with another twice, for example north one goes to south and then south one goes the north to speak again. If one of the neighbors has the alien's virus it has a probability to transfer to the other one according to the virus specification. Then this virus may kill infected people. If a person dies in a certain cell that cell is treated as empty from the next day forward. After this the aliens bomb again trying to infect more people.

Problem 1 (40 points):

Program a probabilistic model of the virus spread on the given territory for a given population according to the above specification. Write a function which calculates how many equipment units will be produced for 1200 days of resistance.

Book keeping: Keep population statistic in the 2D array called 'AreaMap' with the size of the area dimensions. Assign 1 to the empty cell, 2 to the healthy human, 3 to the ill/infected human. I would suggest to have a current population map and another map reflecting a new situation with newly infected people and so on, since a human who was not infected at the beginning of the current day cannot infect another one due to an incubation period.

Hint: it is very useful to look at the area map from time to time during the debugging to see how the virus has spread. Use the following code to output the image of the area.

```
% assigns the black color to the empty cell,
% green to the healthy human, and red to the ill person
population_colormap=[ 0,0,0; 0,1,0; 1,0,0];
image(AreaMap), colormap(population_colormap); % outputs the map image
```

Problem 2 (20 points):

How many people will you take under your command to maximize the number of units of the counter-alien equipment produced in 1200 days? Using the function optimization algorithm (golden search or matlab built in), find the optimal resistance group size. Run your algorithm several times to estimate error bars on this number.

Problem 3 (20 points):

Make a movie of your group map evolution for the optimal group size during the first 200 days. At the beginning of the every **5th** day execute the following

```
population_colormap=[ 0,0,0; 0,1,0; 1,0,0];
image(AreaMap), colormap(population_colormap); % outputs the map image
% frame_counter must start from 1
map_evolution_movie(frame_counter)=getframe;
frame_counter=frame_counter+1;
% this movie can be played with the 'movie' command
% i.e. movie(map_evolution_movie);
```

Save this movie at the very end of the simulation of the virus spread.

```
save('movie_file.mat', 'map_evolution_movie');
```

Attach this movie file 'movie_file.mat' to your electronic submission.

You can check the validity of the movie with the following commands

```
load('movie_file.mat');
movie(map_evolution_movie);
```

Problem 4 (10 points):

For the optimal group size, plot the accumulated production of the counter-alien equipment vs. number of days since the virus introduction. Make sure that you show the interesting transient behavior in the zoomed-in version.

Task 5 (10 points):

For the optimal group size, plot the accumulated number of people killed by the virus vs. the day number. Make sure that you show the interesting transient behavior in the zoomed-in version.