The Percentage of Disease During a Common School Day

New Mexico

Supercomputing Challenge

Final Report

April 7, 2010

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Executive Summary

The purpose of our program is to show the spread of diseases in schools depending on the number of students, size of classes, the number of classes, and relationship links (friends and enemies) as well as transient links (classes) that students have with each other.

This program could benefit many people who run schools like principles, and the school board. It could be used to help them decide, depending on the number of people sick, if they needed to cancel school for the day or offer vaccinations.

Our program has made huge strides in the short amount of time we had to work on it. We have increased the number of agents or students in our program, assigned them a random number between 1 and how ever many classes there were. This creates a class group of students with the same random number which simulates students attending classes at a school. The program then has those students get in groups with their classmates by links. This is accomplished by being able to tell our students-agents to be “friends” or “enemies.” This designation allows differences in behaviors to be represented by our model. These associations are then used to determine the likely hood that class links will appear. (the numbers of classrooms and number of classes per day are also chosen by the user). The friend and enemy agents then establish links depending on the percentages put in by the user. Transient (class) links are then determined by a formula in the program based on the number of students in the class and how many links it would take to get every student in a class linked to every other student. Then it spreads the disease randomly via the class links. Next the students go to their next class until the day is over after which cycle of infection repeats. Once infected students are added the rate of spread of the disease will becomes apparent.

Problem Description

Disease is a serious concern for many people around the world. He seriousness of the H1N1 virus lead our team to become interested in how this type of illness might be spread in a school. We noticed that many students were absent at the beginning of the year and wondered how many more would become sick as time went by. The purpose of our program is to show the spread of diseases in schools depending on the number of students, size of classes, the number of classes, and relationship links (friends and enemies) as well as transient links (classes) that students have with each other.

This program could benefit many people who run schools like principles, and the school board. It could be used to help them decide, depending on the number of people sick, if they needed to cancel school for the day or offer vaccinations. It would also help them to monitor how many students per classroom were becoming ill so that they could keep parents up to date on how serious the spread of the disease was. It could also help school engineers decide how many classrooms to build since this will contribute to how quickly the sick people may come in contact with each other.

In the Health Economist article on Contagious Disease,

CNN reports that H1N1 is still a problem, particularly in the Southeastern U.S. Traditionally, epidmiologists model the spread of a contagious disease based on two factors: the transmission rate between people and the frequency of contact between individuals. Researchers named, Yoo, Kasajima and Bhattacharya (2010) incorporates a third factor that will affect the spread of a disease:

> *We modify this standard model to incorporate avoidance response—that is, the idea that the frequency of contact among individuals will itself depend on the prevalence of the disease in the population.(Yoo. 2010)*

With all these people informed this could drastically change the amount of people that get sick in the common school day and it could change how people behave when coming into contact with each other.

Program Design

In writing this program it is necessary to first determine how the screen or "patches" can be used to show the spread of a disease. Net Logo is being used since it allows the graphics and movements of the individuals to be easily represented. The agents in this program represent students and are given properties based on whether or not they are infected on not; the area of interaction, speed of movement.

The program could model a variety of strains of influenza to entering a totally susceptible population. The spread rate will determine whether or not a school should be closed temporarily.

> "However, as more of the population enters the recovered class and there are fewer susceptible, the disease spreads less well and eventually the number of cases declines. Due to this decline not everyone will be infected before the disease dies out. By looking at the long-term behavior of the SIR model, Kermack and McKendrick were able to predict the proportion of individuals who would escape the infection, "(http://plus.maths.org/issue14/features/diseases/).

Program Description

Our program shows the spread of diseases in a common school day. It does this by creating a predetermined number of students (by the user of the program). Then

We have been able to tell our students to be friends or enemies and use that to determent the likely hood that class links will appear. the virius turns non infecties into infecties throw the links thus it can show the spred of a dease throw class links. Class links can only appear if you're in the same "class" as the other student you're trying to link to, thus this prevents a virus that goes throw walls.

Input

1. Initial infection rate
2. Friend/enemy ratio
3. Number of students
4. Classes
5. Classrooms

Output

1. Speed of infection

2. Changes ratio of link chance
3. The number of students in our world
4. The number of classes that are on a student’s schedule
5. The number of classrooms in the school that students may go to via there scudele

Program Verification

In verifying our program we used the Disease Spread Applet produced by the Environmental Statistics Group. This “is a simple model for disease spread based on direct individual to individual contact. It is a spatially explicit model, a two-dimensional model. The individuals are set out on a 20 by 30 grid, thus with 600 total individuals in the population. Initially, there is some mix of susceptible (S) and immune or resistant (R) individuals in the population. The user controls the initial ratio of S and R individuals. To introduce the disease to the population, the user clicks the mouse on an S individual. The dynamics of the epidemic proceed from this event ("Disease Spread Applet." 2010) . Since this is a spatial model rather than a behavioral one the results were inconclusive.

Conclusions

In our program there were many things that affected the speed of infection, for one the initial infection rate. There is also the size of classes, the number of friend/enemy links and the aggressiveness of the virus.

In the future it could be helpful to add teacher-agents to the program inorder to show the likelihood that teachers will contract the disease. This could help administrators decide how much of a school budget should be devoted to providing substitutes and to anticipate at what part of the disease cycle most of the staff would have to be absent.

Works Cited

"Disease Spread Applet." *Environmental Statistics Group*. W eb. 04 Feb. 2010. <http://www.esg.montana.edu/meg/notebook/example1.html>.

"The Mathematics of Diseases." *Plus Magazine*. Web. 06 Apr. 2010. <http://plus.maths.org/issue14/features/diseases/>.

Yoo, Kasajima. "· Contagious Disease." *Healthcare Economist*. 31 Mar. 2010. Web. 06 Apr. 2010. <http://healthcare-economist.com/category/contagious-disease/>.

Appendix

Program code

```
breed [students student]

undirected-link-breed [transients transient]
undirected-link-breed [friends friend]
undirected-link-breed [enemies enemy]

students-own [
 infected?
 symptomatic?
 schedule
]

friends-own [
 active?
]

enemies-own [
 active?
]

to setup
 no-display
 clear-all
 set-default-shape students "susceptible"
 create-students num-students [
  setup-student-basic
  setup-friends
  setup-enemies
  setup-schedule
 ]
 update-plot
 display
end

to setup-student-basic
 setxy random-xcor random-ycor
 ifelse ((random-float 100) < initial-infection) [
```

```
    set infected? true
    set symptomatic? true
    set shape "symptomatic"
  ]
  [
    set infected? false
    set symptomatic? false
  ]
end

to setup-friends
  if ((random-float 1) < 0.5 * average-friends) [
    create-friend-with one-of ((other students) with [not ((friend-neighbor? myself) or
(enemy-neighbor? myself))]) [
      set color green
    ]
  ]
end

to setup-enemies
  if ((random-float 1) < 0.5 * average-enemies) [
    create-enemy-with one-of ((other students) with [not ((friend-neighbor? myself) or
(enemy-neighbor? myself))]) [
      set color red
    ]
  ]
end

to setup-schedule
  set schedule []
  repeat classes [
    set schedule (fput (random classrooms) schedule)
  ]
end

to go
  advance-classes
  form-classes
  spread-disease
  update-plot
```

```
 tick
end

to form-classes
 ask transients [
  die
 ]
 no-display
 foreach n-values classrooms [?] [
  let class-group (students with [(first schedule) = ?])
  if (any? class-group) [
   let class-size (count class-group)
   repeat (floor ((class-size - 1) * sqrt (class-size / 4.0))) [
    ask one-of class-group with [(count my-transients) < (class-size - 1)] [
     create-transient-with one-of ((other class-group) with [not transient-neighbor?
myself]) [
      hide-link
      set color gray
     ]
    ]
   ]
  ]
 ]
 ask (link-set friends enemies) [
  ifelse ((([first schedule] of end1) = ([first schedule] of end2))
    and (member? end1 [transient-neighbors] of end2)) [
   show-link
   set active? true
  ]
  [
   hide-link
   set active? false
  ]
 ]
 ask transients [
  show-link
 ]
 repeat 100 [
  layout-spring students transients 0.2 1 0.5
 ]
```

```
  display
  repeat 100 [
    layout-spring students transients 0.2 1 0.5
  ]
end

to advance-classes
  ask students [
    let current-class (first schedule)
    set schedule (reverse (fput current-class reverse but-first schedule))
  ]
end

to spread-disease
  let susceptibles (students with [not infected?
      and any? (my-transients with [[infected?] of other-end])])
  ask susceptibles [
    let no-infect-rates ([1 - infection-rate ^ ifelse-value (friend-neighbor? myself) [1 / friend-
factor] [ifelse-value (enemy-neighbor? myself) [enemy-factor] [1]]] of transient-neighbors)
    let prob-no-infect (reduce [?1 * ?2] no-infect-rates)
    if ((random-float 1) < (1 - prob-no-infect)) [
      set infected? true
      set shape "symptomatic"
    ]
  ]
end

to update-plot
  set-current-plot "Population"
  set-current-plot-pen "Infected"
  plot (count students with [infected?])
end
```

Acknowledgements

Debra Loftin our sponsor

Nick Bennett our Mentor