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Etude 10: Epidemic

- Given an initial universe containing only immune and vulnerable individuals, determine the minimum number of individuals who must initially be made sick so that eventually every non-immune individual becomes sick.

Universe without immune individuals

If the universe is 'two-dimensional' the minimum number to make sick is every second individual on the top row and every second individual in the first column starting from the second row if the row length is even and starting from the third row if the row length is odd. This results in the following equations.

initSick = initial individuals who must be made initially sick
row = number of rows in universe grid
col = number of columns in universe grid

In 2D universe:

initSick = roundUp((row+col)/2)

The same applies if the universe is 'one-dimensional' as well, but row will be equal to one. So the simplified equation is:

In 1D universe:

initSick = roundUp(col/2)

Universe with immune individuals

In a one dimensional universe, you would search for all vulnerable individuals with less than two vulnerable neighbours (so only one neighbour or at least one immune neighbour), count them and make them initially sick. After making these individuals sick you would look for the first chain of one of more vulnerable individual starting from the left. If the chain has a length of one, you would skip to the next chain as both this individuals neighbours would be sick. If the chain had a length of two or more you would and was odd you would add (n-1)/2 to count and find the next chain, or add n/2 to the count if even and find the next chain. After all chains have been checked the count which should be the minimum number of individuals who must be made sick.

In a two dimensional universe you would find all the combinations of vulnerable individuals in the universe being initially sick or not sick initially. Unless there were only two vulnerable individuals in the grid you would start by making two sick. You would start at the top two left most vulnerable individual and make them sick, then check if this results in all individuals being sick. If not you'd check the next top leftmost vulnerable individual and the next vulnerable to the right and check then so on. Once all vulnerable individuals had been checked and not all other vulnerable individuals became sick you would then make three individuals sick starting with the three top left most and then going through all vulnerable individuals left after it. If all individuals are sick after a combination then count how many were initially sick in this combination and this will be the minimum number of individuals who must be made sick. An example of this is illustrated below.

Initial

.	.	.
.	.	I
.	I	I

initSick = 2

state1:	check(state1):	not all sick so go next state
SS. ..I .II	SS. ..I .II	

... check

state5:	check(state5):	not all sick so go next state
S.. ..I SII	S.. S.I SII	two state for individual exhausted so move to next starting position

state6:	check(state6):	not all sick so go next state
.SS ..I .II	.SS ..I .II	

... all 2 initSick exhausted so initSick+=1 and start making 3 individuals sick

initSick = 3

state22:	check(state22):	all sick so initSick = 3
S.S ..I SII	SSS SSI SII	

where:

initSick = 2

state 1

S	S	.
.	.	I
.	I	I

state 2

S	.	S
.	.	I
.	I	I

state 3

S	.	.
S	.	I
.	I	I

state 4

S	.	.
.	S	I
.	I	I

state 5

S	.	.
.	.	I
S	I	I

state 6

.	S	S
.	.	I
.	I	I

state 7

.	S	.
S	.	I
.	I	I

state 8

.	S	.
.	S	I
.	I	I

state 9

.	S	.
.	.	I
S	I	I

state 10

.	.	S
S	.	I
.	I	I

state 11

.	.	S
.	S	I
.	I	I

state 12

.	.	S
.	.	I
S	I	I

state 13

.	.	.
S	S	I
.	I	I

state 14

.	.	.
S	.	I
S	I	I

state 15

.	.	.
.	S	I
S	I	I

initSick = 3

state 16

S	S	S
.	.	I
.	I	I

state 17

S	S	.
S	.	I
.	I	I

state 18

S	S	.
.	S	I
.	I	I

state 19

S	S	.
.	.	I
S	I	I

state 20

S	.	S
S	.	I
.	I	I

state 21

S	.	S
.	S	I
.	I	I

state 22

S	.	S
.	.	I
S	I	I

state 23

S	.	.
S	S	I
.	I	I

state 24

S	.	.
S	.	I
S	I	I

state 25

S	.	.
.	S	I
S	I	I

state 26

.	S	S
S	.	I
.	I	I

state 27

.	S	S
.	S	I
.	I	I

state 28

.	S	S
.	.	I
S	I	I

state 29

.	S	.
S	S	I
.	I	I

state 30

.	S	.
S	.	I
S	I	I

state 31

.	S	.
.	S	I
S	I	I

state 32

.	.	S
S	S	I
.	I	I

state 33

.	.	S
S	.	I
S	I	I

state 34

.	.	S
.	S	I
S	I	I

state 35

.	.	.
S	S	I
S	I	I