Inferno

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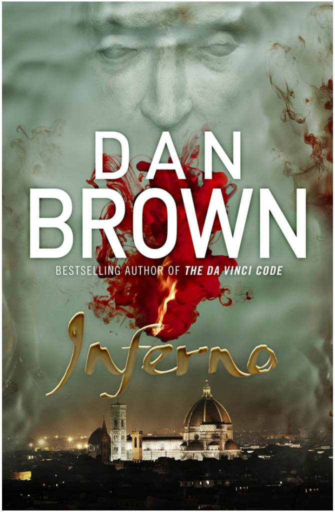
Outline



Motivation

- Bioweapons are the future of weaponry
- Better understand how to model diseases
- Is Hollywood real?

Thomas Robert Malthus

The power of population is so superior to the power of the earth to produce subsistence for man, that premature death must in some shape or other visit the human race ... But should they fail in this war of extermination, sickly seasons, epidemics, pestilence, and plague advance in terrific array, and sweep off their thousands and tens of thousands. Should success be still incomplete, gigantic inevitable famine stalks in the rear, and with one mighty blow levels the population with the food of the world.

-An Essay on the Principle of Population. Chapter VII, p 44

Population Models

Malthusian Growth model:

$P(t) = P_0 e^{rt}$

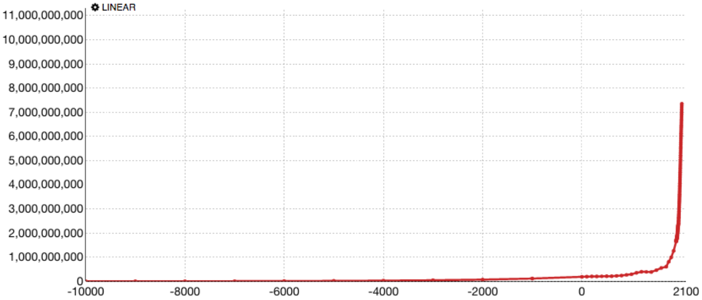
where r is called the Malthusian parameter.

Logistic Growth model:

$\frac{dP}{dt} = rP(1 - \frac{P}{K})$

where K is called the carrying capacity.

Overpopulation



(Source: https://ourworldindata.org/world-population-growth/)

SIR Model

$$\frac{dS}{dt} = -\frac{\beta}{N} S(t) I(t)$$

$$\frac{dI}{dt} = -\frac{\beta}{N} S(t) I(t) - \gamma I(t)$$

$$\frac{dR}{dt} = \gamma I(t)$$

R Code

Using R, the goal is to use the outbreak data to get beta and gamma to figure out R_0.

Results

```
Parameters:
      Estimate Std. Error t value Pr(>|t|)
beta   4.99910    0.06137   81.46   <2e-16 ***
gamma  4.76444    0.06012   79.25   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 78110000 on 248 degrees of freedom
Number of iterations to termination: 26
Reason for termination: Relative error in the sum of squares is at most `ftol'.
> confint(fitval) #print confidence intervals
        2.5 %   97.5 %
beta  4.87882 5.119387
gamma 4.64660 4.882277
```

Basic Reproduction Number

$$R_0 = \frac{\beta}{\gamma} = \frac{0.5(4.87882+5.119387)}{0.5(4.64660+4.882277)} = \frac{4.9991035}{4.7644385} = 1.04925344$$

Final Size

$$\frac{dI}{dS} = \frac{\frac{\beta}{N}S(t)I(t) - \gamma I(t)}{-\frac{\beta}{N}S(t)I(t)} = -1 + \frac{\gamma N}{\beta S(t)}$$

$$-dI = (1 - \frac{\gamma N}{\beta S(t)})(dS)$$

$$\int_0^\infty -I' = \int_\infty^0 S' - \frac{\gamma N}{\beta}\int_0^\infty \frac{S'}{S}$$

$$ln(\frac{S_0}{S_\infty}) = \frac{\beta}{\gamma N}[1 - \frac{S_\infty}{N}] = \frac{R_0}{N}[1 - \frac{S_\infty}{N}]$$

Results

$N := 7.5 \cdot 10^9$

$\ln(N) - \ln(S) = \frac{1.05}{N}(N - S)$

$solve\left(\ln(N) - \ln(S) = \frac{1.05(N - S)}{N}, S\right)$

$N := 7.500000000\ 10^9$

$22.73816886 - \ln(S) = 1.050000000 - 1.400000000\ 10^{-10}\ S$

$6.797236575\ 10^9, 7.499999623\ 10^9$

Overpopulation

Would his plan have worked?

The film


THE DA VINCI CODE AND ANGELS & DEMONS
WERE JUST THE BEGINNING
TOM HANKS
INFERNO
HIS GREATEST CHALLENGE.
HUMANITY'S LAST HOPE.

Conclusion

Thank you very much for listening.

Any questions?