

Project 3 Due Friday by 4pm. (Questions?)

Hand in HW - math models of love

Change Due Date - Final Project

Intro / Assumptions Due Thursday 10/27

Applied Math.
TALK 10/19

TODAY: Stochastic Models

Deterministic - no random events or variance in populations.

$$x(n+1) = r x(n)$$

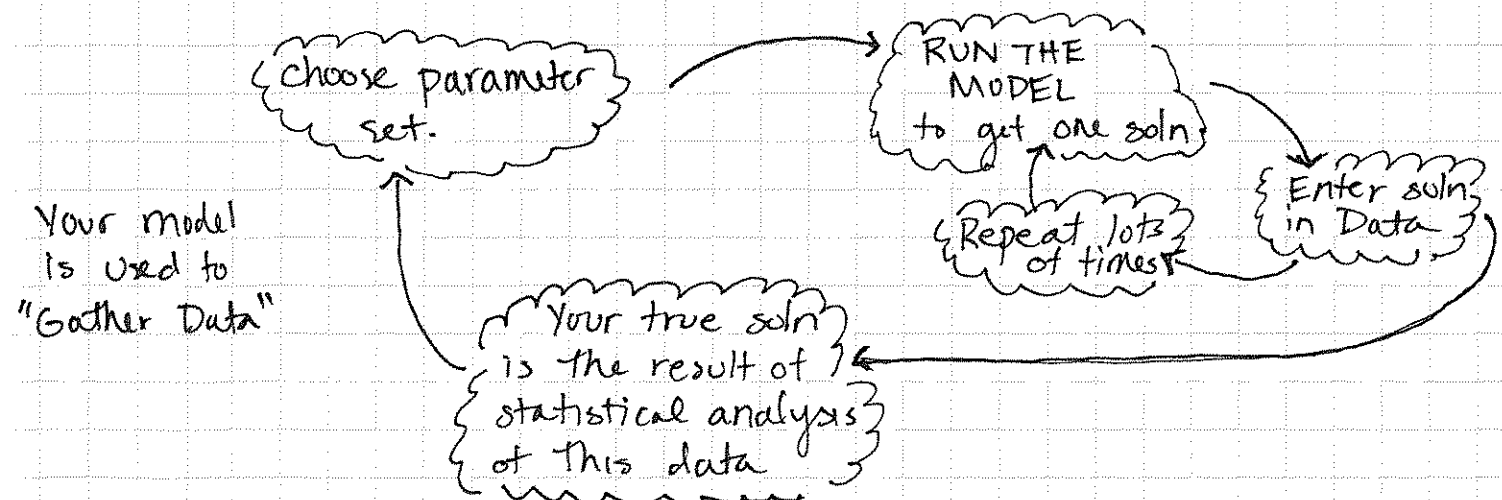
↑ the whole population follows one growth rate.

Program a spreadsheet to give us one curve or number as our soln for each variable.

Stochastic - allow for randomness.

- Environmental Stochasticity - floods, drought, fire, or changes in carrying capacity.
- Demographic Stochasticity - variance in the populations behavior or structure.

★ STOCHASTIC SIMULATIONS: When you run a simulation you get a slightly different answer each time.



REAL LIFE EXAMPLES

- A basketball player hits 75% of his free throws

- Does he always hit 3 then miss one?
- If he hits three is he more likely to miss the next?
- How did we get this 75% number?

- Chance of Winning The CA Lotto.

1 in 18 million $\rightarrow$ if you buy 18 million tickets are you sure to win?

- A Quarter has 50/50 chance to land on either side.

- Does this mean it goes: heads, tails, heads...

Important Ideas - when dealing with statistics, basic chance, it doesn't matter what the last result was... things are random.

- only by gathering LOTS of data do we get good reliable numbers.

We will need to interpret noisy data ... Statistics!

Main Ideas: Measure of Middle
Measure of Spread
Skew in the Data
Outliers in the Data.

CENTER

Mean $\longrightarrow$

SPREAD

Standard Deviation

SKEW

mean and median do not match up

OR

HISTOGRAM (Frequency Distribution)

Median $\longrightarrow$

Interquartile range
IQR

OUTLIERS: based on $1.5 \times \text{IQR}$.

BOX AND WHISKERS PLOT

* REVIEW OF STATISTICS - WEDNESDAY 5:00 PM.

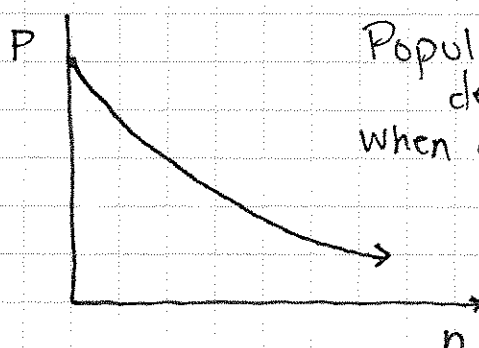
EX - STOCHASTIC MODEL - Squirrels in a City Park.

- The squirrel population is declining
- A grounds keeper has been keeping track of the population and thinks that the population is declining by 50% each year.

$$r = -0.5 \quad \text{and} \quad P(0) = 50$$

Then Deterministically - $P(n+1) = P(n) - 0.5 P(n)$
 $P(n+1) = 0.5 P(n)$

Year	Population
0	50
1	25
2	12.5
3	6.25
4	3.13
5	1.56
6	.78
7	.2
8	.1



Population is decreasing.
When are they "extinct"?

PROBLEMS: In reality 50% can't die each year there is some fluctuation.

IN REALITY...

maybe each squirrel has a 50% chance of surviving the year.

What is .2 of an animal?
Does the population ever reach zero?

Break into Groups - Stochastic Squirrels.

Math 231

Stochastic Squirrels - Part 1

This lab has two parts. First, you will collect data and statistically analyze that data. Then, you will build a stochastic simulation that models the data. This will allow you to compare the real life data and your simulated data.

DATA COLLECTION

We will begin by collecting some data. Each group should have a stack of 50 squirrels. Think of this as $P(0) = 50$. To simulate the death of squirrels we will be throwing the squirrels into the air. If they land face up they survived. If they land face down they did not survive and should be removed from the population. Each time you throw the squirrels in the air it simulates one year of their lives with a 50% survival rate. In our shared class spreadsheet, enter your values going down the columns. Here you will log your data. Please "flip" your squirrels for $n = 10$ years or until the population reaches zero. This first set of data is your first simulation.

Repeat your squirrel killing simulations to get a decent amount of data to analyze. (Between 3-5 simulations is good since we are sharing data)

Once everyone is done with their simulations, copy and paste all of the data into YOUR OWN spreadsheet and try to answer the following questions:

- What was the average population each year?
- What was the standard deviation of population each year?
- What percent of the population, on average, did not survive each year?
- How do these values compare to the deterministic model that we did in class with 50 percent death rate? NOTE you can build the 50 percent survival rate model very easily: $P(n + 1) = 0.5P(n)$ and calculate values. Then plot this line along with lines for each of your simulations.

SOME HELPFUL SPREADSHEET COMMANDS:

`=average(B1:K1)` → finds the average of the values along the first row.
`=stdev(B1:K1)` → finds the standard deviation of the row of values.
`=median(B1:K1)` → finds the median of the row of values.
`=quartile(B1:K1,1)` → finds the first quartile of the row of values.
`=quartile(B1:K1,3)` → finds the third quartile of the row of values.
`=rand()` → generates a random number between 0 and 1. (Uniformly Distributed)
`=if(rand<0.5,0,1)` → generates a random number and tests if it is less than 0.5. Output of zero means less than 0.5 output of one means greater than 0.5.

Math 231
Stochastic Squirrels - Part 2
MODEL BUILDING

Now we can try to build our first stochastic model. (NOTE my example spreadsheet is available on the class Website.)

Follow the directions carefully to build your first stochastic simulation.

- At the top of the spreadsheet, in cell C3, enter your one and only parameter: Probability of survival $s = 0.5$, meaning the squirrels have a 50 percent chance of surviving each year.
- Now Build a table where you will collect the “simulation data”. The first make a column named YEAR with the numbers 0-10 and then make a second column named POPULATION. In the first entry for population type 50, since we start with 50 animals. Leave the rest of the population column blank for now.

SIMULATION OF RANDOM EVENTS

- In cell E1 type the word SQUIRRELS. In cell F1 type YEAR 1, and cell G1 type YEAR 2, and so on until you have 10 years.
- In the column cells below SQUIRRELS, enter the numbers 1-50, to simulate the 50 squirrels that you start with.
- In cell F2 below the heading YEAR 1 type: `=if(rand()<$C$3,0,1)`. Copy this down the column for all 50 squirrels. This will simulate the first flip.
- In cell G2 below the heading YEAR 2 type: `=if(F2=0,0,if(rand()<$C$3,0,1))`. Copy this down the column for all 50 squirrels. This will simulate the second flip. If the first flip resulted in a zero then the second results remains zero, since we remove the dead squirrels, otherwise they have a 50% chance of survival.
- Drag cell G2 across for the other YEARS and then down for all the squirrels. This should fill out a table of zeros and ones.
- At the bottom of the zeros and ones table, we need to count the number of survivors. Do this by summing the cells above. For example in cells F52 type `=sum(F2:F51)` and so on to get the population count each year.

Your simulation is complete. Now in your small table of values where you have a column named POPULATION tell those cells to look at the bottom of the simulation to see what the population is at each time step. This gives you ONE SIMULATION.

MULTIPLE SIMULATIONS. Go to a new sheet and call it DATA COLLECTION. To refresh the random numbers (aka do a new simulation) type into any cell in the spreadsheet. Copy the data in the POPULATION column and PASTE SPECIAL NUMBERS ONLY into the DATA COLLECTION sheet, this will record separate simulations. Do this 10 times for 10 different simulations.

- Find the average and standard deviation of the population each year.
- How does this compare to your real life “squirrel flips”?