Evaluation of Mathematical Models

In what ways can a model be “good”? A model can be...

- **Accurate**
  - Is the output of the model very near to correct?
- **Descriptively Realistic**
  - Is the model based on assumptions which are correct?
- **Precise**
  - Are the predictors of the model definite numbers?
- **Robust**
  - Is the model relatively immune to errors in the input data?
- **General**
  - Does the model apply to a wide variety of situations?
- **Fruitful**
  - Are the conclusions useful?
  - Does the model inspire other good models?

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This year, there are 5 million students. (S)

We might conjecture that in general, $S = 0.5P$.

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Model Assumption 1: Each college student is in 18–22 year old range.

Model Assumption 2: One of every two is enrolled in college.

If next year there are projected to be $11,000,000$ 18–22 year olds, we would estimate the college population to be of size $E =$ ______.

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Question: Is this model descriptively realistic?

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Descriptively Realistic

Example. A more descriptively realistic model would incorporate other age groups. Replace Assumptions 1 and 2 by:

Model Assumption 3: College students are either:

- 18–22 (P_a of these)
- 23 or older (P_b of these)
- 17 or younger (P_c of these)

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Model Assumption 4: The enrolled percentages for each age range is:

- 30% for people aged 18–22
- 3% for people aged 23 or older
- 1% for people aged 17 or younger

We would estimate the college population to be of size

$$E = 0.3P_a + 0.03P_b + 0.01P_b.$$

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Revise Assumption 2*: The percentage of 18–22 year olds in college is between 46% and 50%. (Historically)

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This model is imprecise, but perhaps more helpful than the precise answer from before.

Robustness and Percentage Error

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Ask: Is the output error less than 10% or more than 10%?

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Make sure we understand: What does 10% error mean?

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$$11,000,000 = 1.05P \implies P = 10,475,190$$

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$$E = 0.5P = 0.5(10,475,190) = 5,238,095,$$

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This highlights the principle of "Error In equals Error Out"

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Then comparing the true enrollment to the estimated enrollment E':

$$E = 0.3(10) + 0.03(90) + 0.01(50) = 6.2$$
$$E' = 0.3(11) + 0.03(99) + 0.01(55) = 6.82$$

Percentage error: $\frac{6.82 - 6.2}{6.2} = \frac{.62}{6.2} = 10\%$;

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Suppose that Queens College has 20,000 students and suppose that Private UNnamed Kansas College has 2,000 students this year.

If the year-to-year change in 18–22 year old population is 10%, then QC would gain 2,000 students while PUNK College would gain 200.

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This model is more general because it applies to individual colleges.

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Example. How many automobiles would be junked in a given year?

- Cars play the role of people.
- Partitioning by age of cars gives better results

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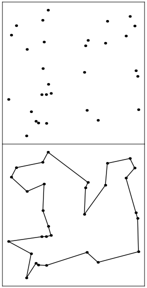
Example. The Traveling Salesman Problem

TSP: Given a home location and a set of places to visit, find the shortest path that starts and ends at home and visits each of the places along the way.



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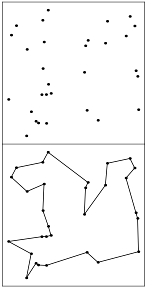

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With many locations, there are (inexpensive and inaccurate) or (expensive and accurate) algorithms to solve these problems.

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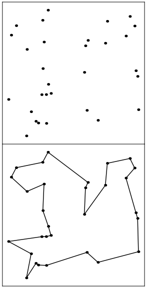

With many locations, there are (inexpensive and inaccurate) or (expensive and accurate) algorithms to solve these problems.

Your approach will depend on the particular application and your scale:

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Accurate
Real
Precise
Robust
General
Fruitful

Often accuracy is very expensive (either computationally or financially).

Example. The Traveling Salesman Problem

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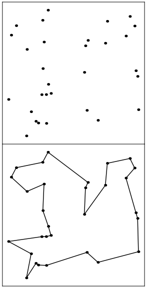

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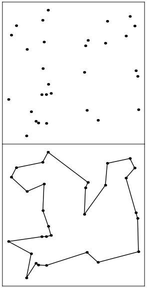

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- If you visit different places every day, run the inexpensive algorithm daily. (Unless you're UPS or FedEx.)