What is Operations Research!?

(. . . or what i think about when i think about work)

Sid Banerjee

CURIE academy, July 2021

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- Mechanical engineering = mechanical stuff
- Electrical engineering = electrical/electronic stuff
- Biomedical engineering = bio stuff
- Aerospace engineering = stuff which fly through air/in space

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- Mechanical engineering = mechanical stuff
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- Aerospace engineering = stuff which fly through air/in space
- Civil engineering = civilian stuff (buildings, transportation, etc.)

by that logic. . .

If not that, then what is Operations Research?

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The basic aim of OR can be summarized as follows:

learn from data

to

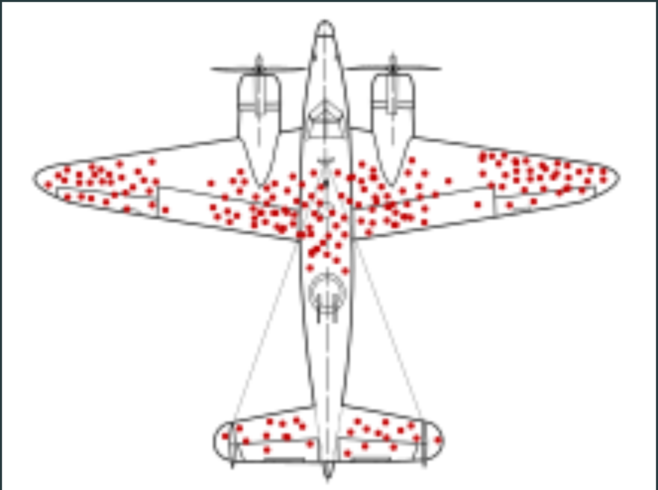
build models

for

making better decisions

An example (and some history)

the name comes from the original application in military operations



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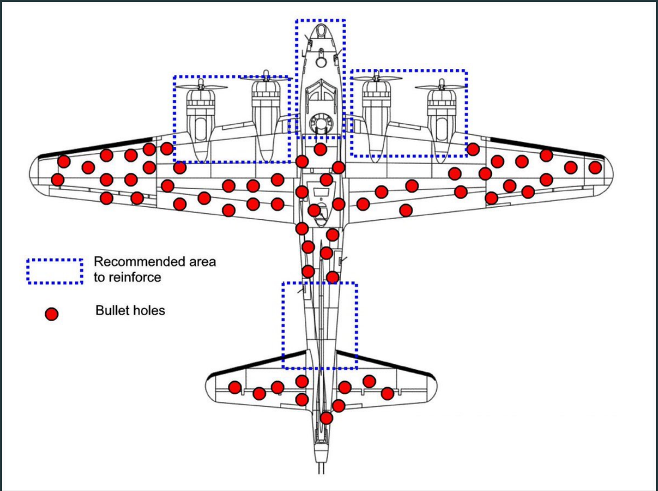

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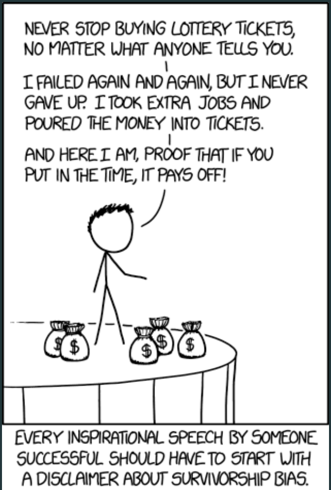


The OR mantra

learn from data

Statistics, ML, data mining, etc

to

build models

$\boxed{\text{Simulation, applied probability}}$, game theory, microecon, operations management

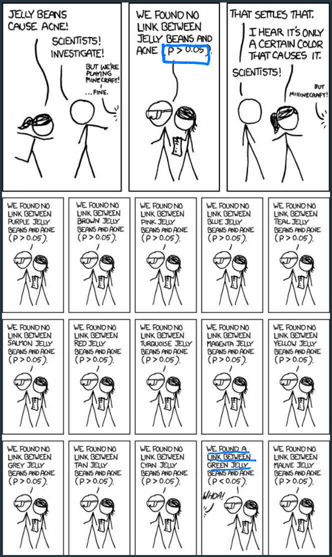
for

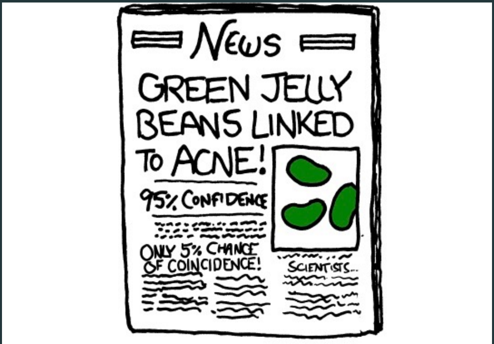
making better decisions

Optimization
- linear / integer programming
- 'stochastic' optim

What does an Operations Researcher think about?

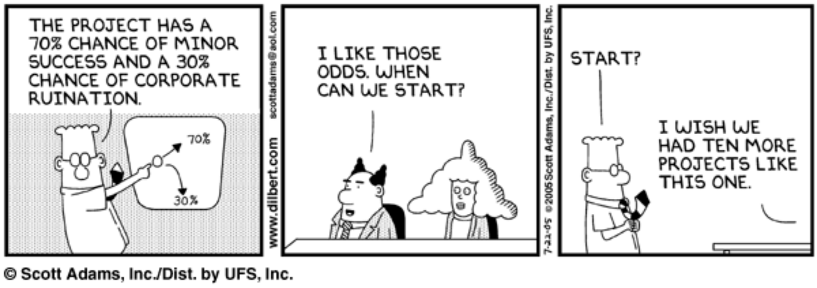
Understanding randomness and sampling





What are the fundamental misunderstandings here?

Risk Analysis: Choosing Projects

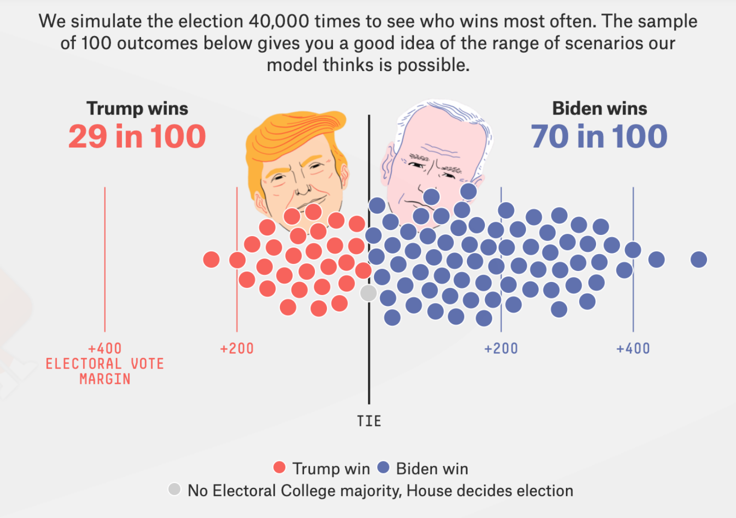


What are the fundamental misunderstandings here?

The project has a 70% chance of success. Why not try?

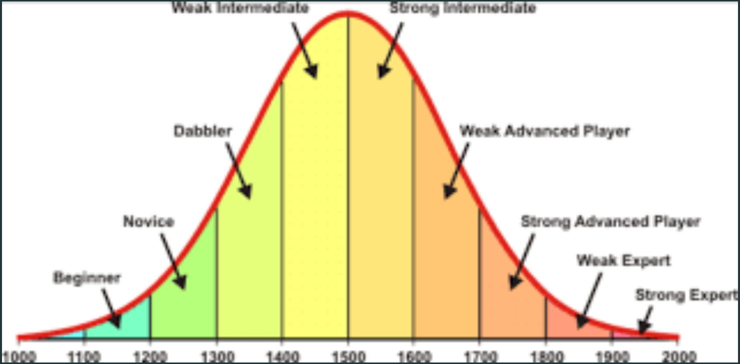
Why not increase the chance of a success by doing 10?

Prediction

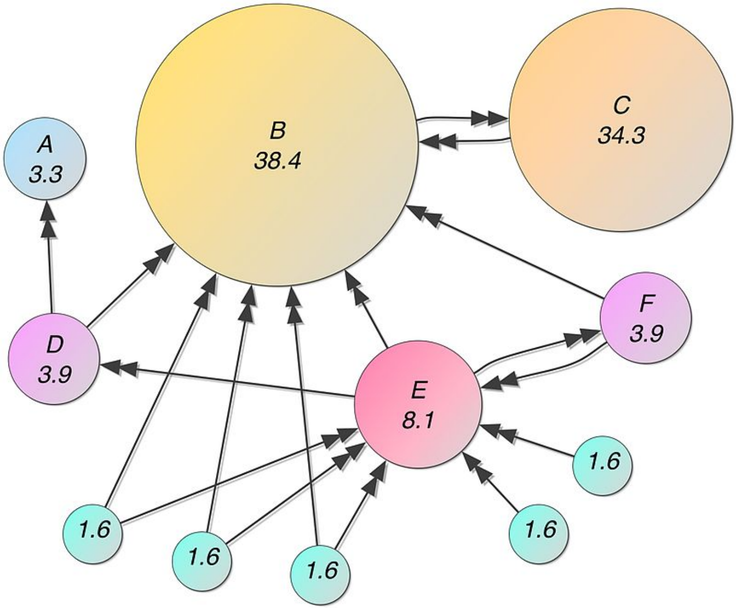

We simulate the election 40,000 times to see who wins most often. The sample of 100 outcomes below gives you a good idea of the range of scenarios our model thinks is possible.
Trump wins
29 in 100
Biden wins
70 in 100
+400
ELECTORAL VOTE MARGIN
+200
+200
+400
TIE
Trump win
Biden win
No Electoral College majority, House decides election

Quantifying Quality

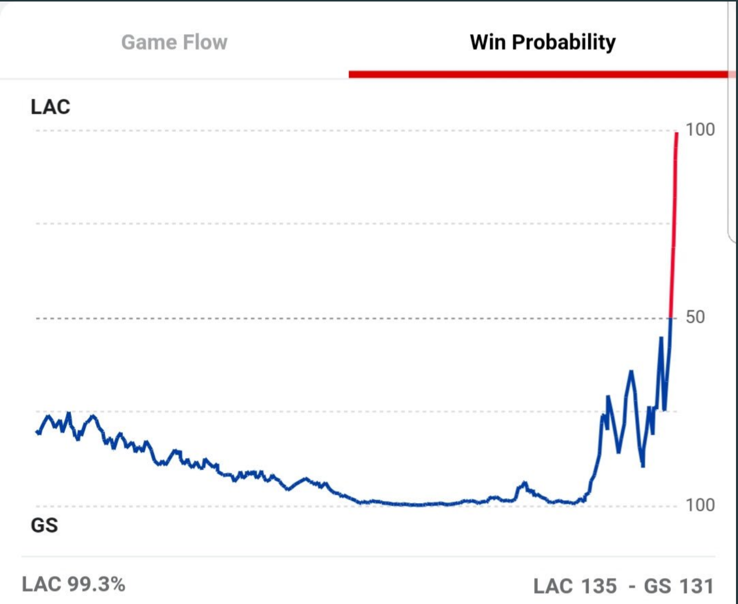
ELO Rankings



Quantifying Utility 'Pagerank'

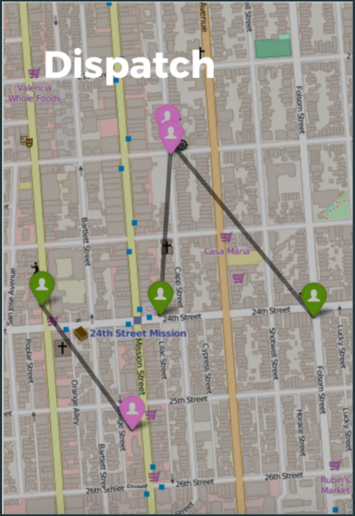


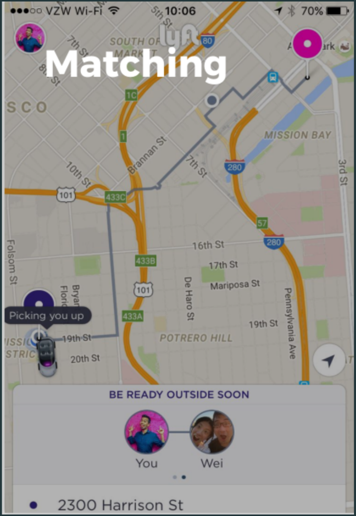
Surprise!


Game Flow
Win Probability
LAC
100
50
100
GS
LAC 99.3%
LAC 135 - GS 131

Designing complex systems

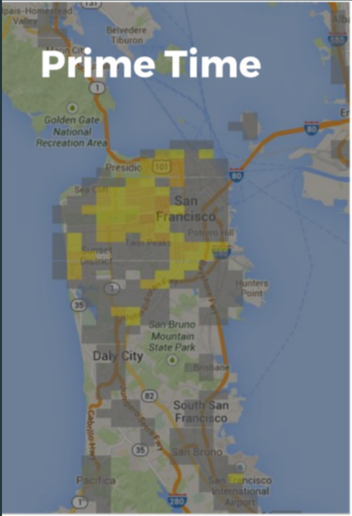
research in ridesharing: logistics

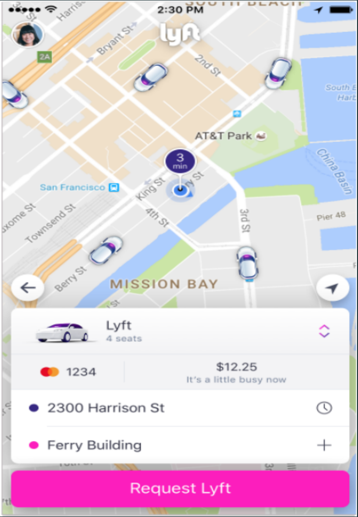




credit: lyft research science

research in ridesharing: market design





credit: lyft research science

Counterfactual Analysis

COVID-19 Mathematical Modeling for Cornell's Fall Semester

PhD Students: J. Massey Cashore, Ning Duan, Alyf Janmohamed, Jiayue Wan, Yujia Zhang
Faculty: Shane Henderson, David Shmoys, Peter Frazier*

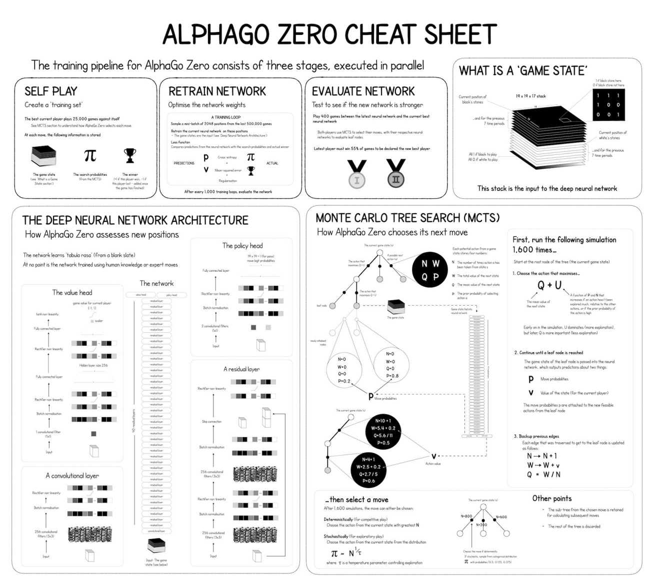
June 15, 2020

Executive Summary:

- Initial modeling results suggest that a combination of contact tracing, asymptomatic surveillance, and low initial prevalence (supported through testing students prior to, and upon, returning to campus) can achieve meaningful control over outbreaks on Cornell's Ithaca campus in the fall semester if asymptomatic surveillance is sufficiently frequent and if we have sufficient quarantine capacity. This would dovetail with a complementary effort at Cornell to reduce transmissions through housing policy, class organization, and regulations on social gatherings.

- We use our model to predict outcomes for a full return of students, faculty and staff in the fall semester over a 16 week time period, with cases imported from returning students and from Tompkins county, counterbalanced by aggressive asymptomatic surveillance where every member of the campus community is tested every 5 days. The course of the epidemic is random and we directly model that randomness. Accordingly, our model produces a range of potential futures. In the median random potential future, under our nominal set of parameters, 3.6% of the campus population (1254 people) become infected, and 0.047% of the campus population (16 people) require hospitalization. The 90% quantile rises to 4.02% infected and 0.051% requiring hospitalization. Of the 1254 infections in the median outcome, 570 are due to direct outside infections and ensuing additional infections prior to isolation, while 31 (0.09% of the campus population) are infected before arrival to campus but missed in the test-on-return protocol. There are an additional set of people infected before arrival, found through test-on-

. . . and beyond: Optimization, control and RL Reinforcement Learning



sbanerjee@cornell.edu