Course Introduction & Stochastic Simulation

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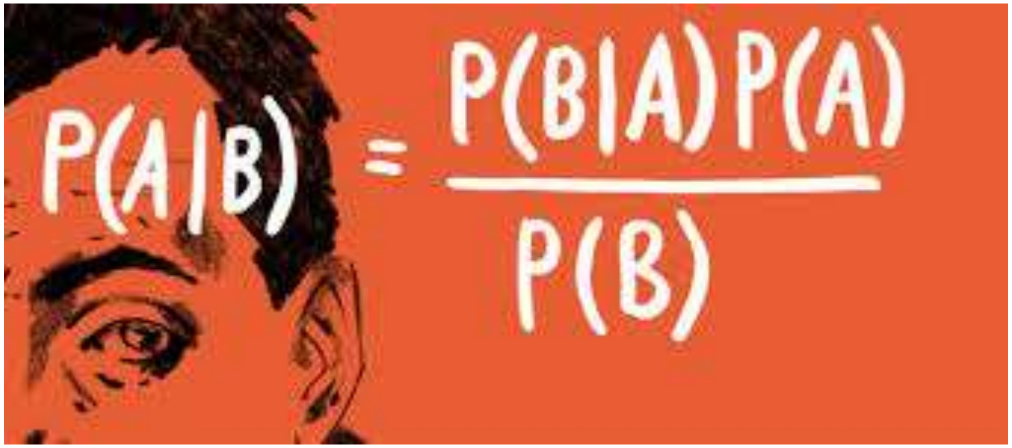
Something about Me

- Student life at Texas
  - major: operations management
  - minor: statistics

Howard Chuang

- *Teach <u>mental gymnastics</u>* at NCCU
  - management science
  - decision science
  - advanced quantitative methods
- Personal facts
  - a nice…liberal but demanding(O) professor
  - a fan of hiking, driving, biking, & traveling
    - Penghu, Taitung, & Kyoto are the best!
  - a lover of coffee, coke, & beer
  - wish to be a Texas Poker player after retirement
- Dream big? Start small, think deep, & be good



Let's go over the Syllabus!

fear NOT & work HARD

Decision Science in Action

time Ubike / Uber traffic speed

- For key performance outcome $\underline{Y}=f(X\ ,\ Z;\ c)$
  - analyze how two sets of variables – controllable X & non-controllable Z – and parameters c affect Y
    - low-dim or high-dim X? deterministic or stochastic Z?

      經驗,
    - need to estimate c from subjective/objective data
  - probability distributions for stochasticity/uncertainty
    - well-defined or unknown $f(\ )$?
    - machine learning/deep learning for unknown $f(\ )$
  - $f(\ )$ may be 1 or >1 equations for a problem or system
  - finally, try to optimize or improve X

Predictive modelling

- Estimate the target for new observations

$$y = f(x)$$

Explanatory modelling

- Describe the effect that a change of certain inputs has on the target

$$y = f(x)$$

Optimisation

- Find the inputs that give optimal performance
- f is known

$$y = f(x)$$

Simulation for Outcome Estimation

- **Monte Carlo (蒙地卡羅) simulation** is 用电脑做重複抽樣
  - for estimating the value of an *unknown quantity* using **repeated random sampling**
    - Ulam & Von Neumann(馮紐曼) at the Manhattan project (曼哈頓計畫) in 1940s for solitaire (接龍)

ex:
21点

strategy {1, 2, 3 張

Simulation for Outcome Estimation

- **Monte Carlo (蒙地卡羅) simulation is**
  - **for estimating the value of an *unknown quantity* using repeated random sampling**
    - **Ulam & Von Neumann(馮紐曼) at the Manhattan project (曼哈頓計畫) in 1940s for solitaire (接龍)**
  - **Experiment: Simulate a system or process with *uncertain/random/stochastic* outcomes for S times Every time we keep records of key metrics (e.g., cost, profit) or the occurrence of an event (E). As we have a sampling distribution of *S* observations, we can do simple calculation to obtain**
    - **sample average**
    - **P(E) (i.e., probability of E occurring)**
    - **sample variance**
  - **Law of Large Numbers: When *S* approaches infinity, sample estimates are close to population true values**

Simulation for Outcome Estimation

- Toss a FAIR coin (擲銅板)
  - event, E: Head shows up
    - what is *P*(E)? $\frac{1}{2}$
  - simulate the process for S times
    - S=10, 100, 10000, or…?
  - if output variability (變異度) is high, confidence (信心) in estimate will be low

    每一次的結果差異大
- A coin-tossing game (銅板賭局)
  - KoP & Han toss a coin 50 rounds, Head KoP+$1, Tail koP-$1, KoP begins with $0 in his pocket
    - How likely KoP breaks even? What is E (event) here?
  - can't we just do the math? why computer simulation?
    - What is the # of rounds KoP has > $0 in the game?
    - What is KoP's highest fortune in the game?
    - Will KoP's max cumulative earning > $10?

Simulation for Outcome Estimation

HW:

Sep 13

- Toss a FAIR die (擲骰子)
  - KoP & Han in turn throw a die. In each round, one of three possible outcomes – b, s, & t – may occur
    - b: KoP bigger, s: KoP smaller, t: KoP & Han tie
  - KoP & Han do this for R rounds in a game. If the # of b > # of s in R rounds, KoP will be the game-winner
- Define E: KoP wins the game
  - what is the exact P(E) mathematically?
  - can you use simulation to estimate P(E)?
    - show $P(E)^{exact}$ & $P(E)^{sim}$ for R=[5, 10, 15,…, 95, 100]
    - what's the impact of S on approximation error?