Why Decision Optimization is important

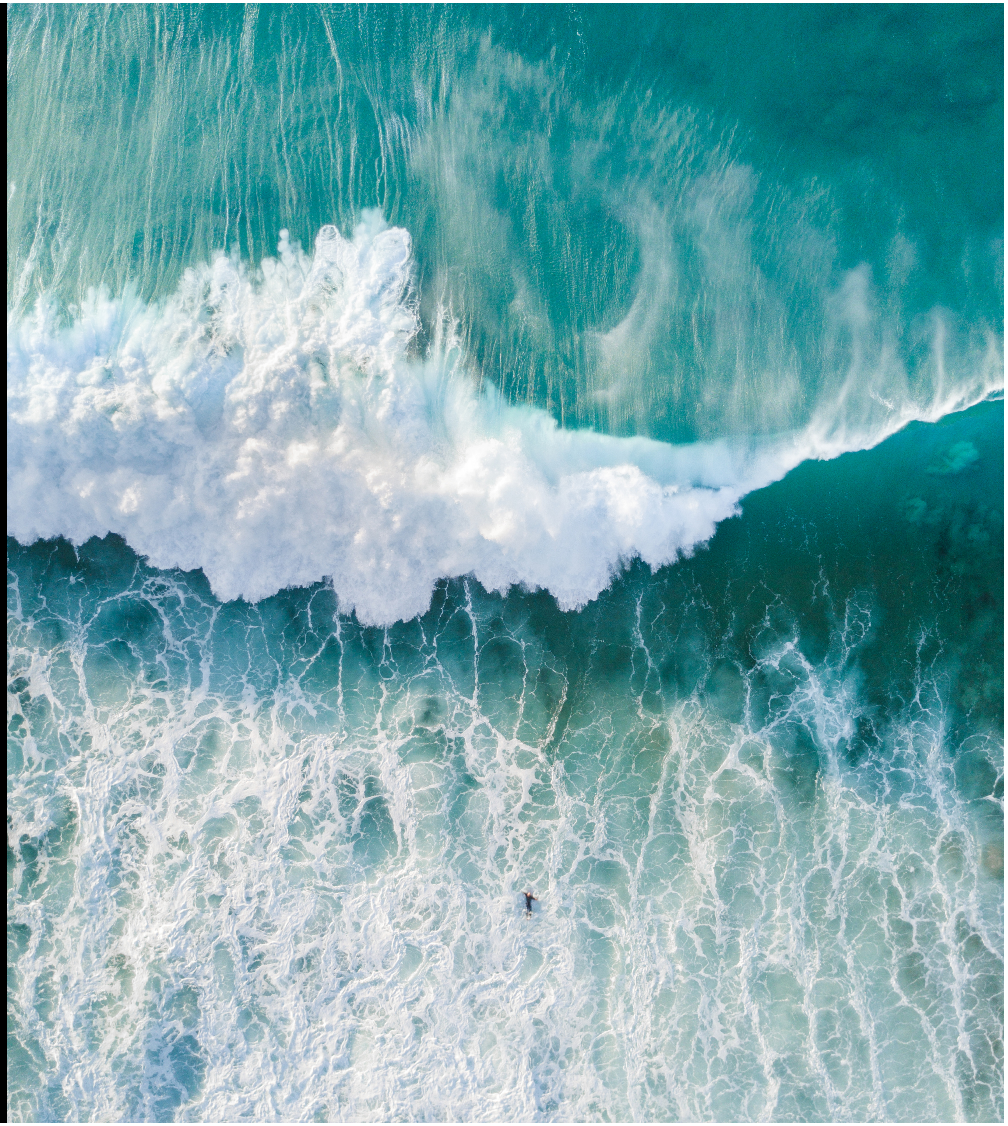
“Everything should be made as simple as possible, but not one bit simpler.”

Albert Einstein, (attributed)

“All models are wrong, but some are useful.”

George Box

Machine Learning is eating the world...



There is more & more data.

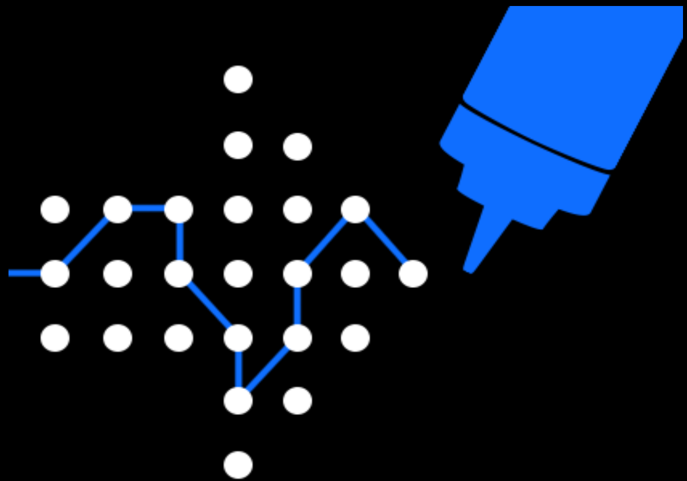
We draw insights from that data using machine learning

to make better decisions.

And then...

...we decide based on our guts : (

Instead, we can leverage the insights and data we got…



… and use mathematical optimization to plan for better, data-driven actions.

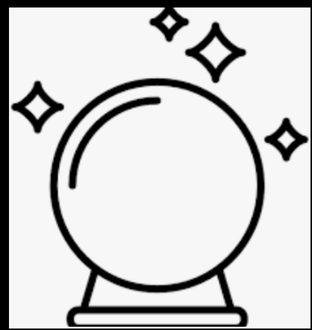
And the tool for that is Decision Optimization feature on Watson Studio.

Descriptive

What happened

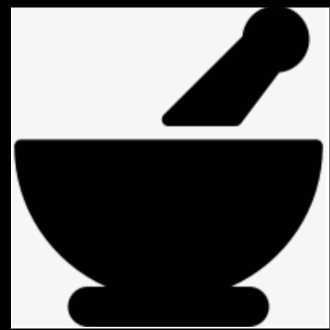
Predictive

What will happen

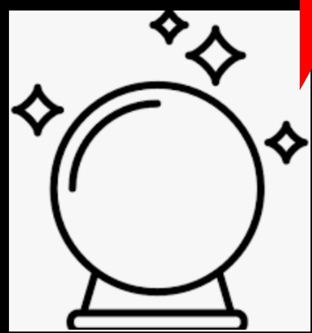


Prescriptive

What you’ll do



Decision Optimization

Descriptive	Predictive	Prescriptive
What happened	What w	What you'll do
		

Use cases for Decision Optimization are everywhere

Because we have limitations everywhere:

- time
- number of attempts to client
- number of people
- etc.

naming just few of them:

- product modeling
- worker shifts planning
- production planning
- marketing campaign planning
- managing sales activities
- choosing best offering portfolio for clients
- and more

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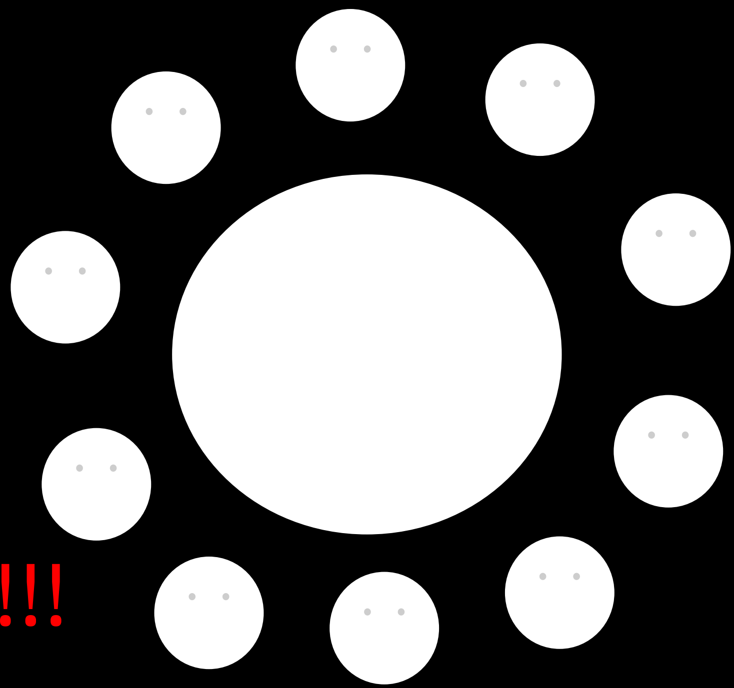
Mathematical Optimization

basic concepts

Optimization is hard:

- It tricks intuition
- It is hard to compute



10 factorial !!!

Source: MIT open course - https://ocw.mit.edu/courses/sloan-school-of-management/15-053-optimization-methods-in-management-science-spring-2013/lecture-notes/

Optimization is Everywhere

Personal choices
– best career choices,
– best use of your time
– best strategies,
– best value for the dollar

Company choices
– maximize value to shareholders
– determine optimal mix of products or services
– minimize production costs
– minimize cost of getting product to customers
– maximize value of advertising
– hire the best workers

Source: MIT open course - https://ocw.mit.edu/courses/sloan-school-of-management/15-053-optimization-methods-in-management-science-spring-2013/lecture-notes/

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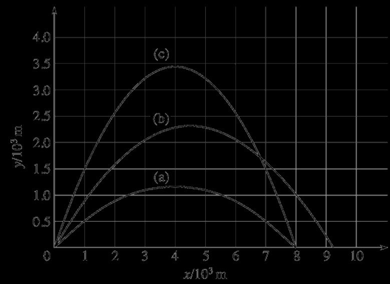
(data)

You will see it everywhere but not instantly!

(algorithm)

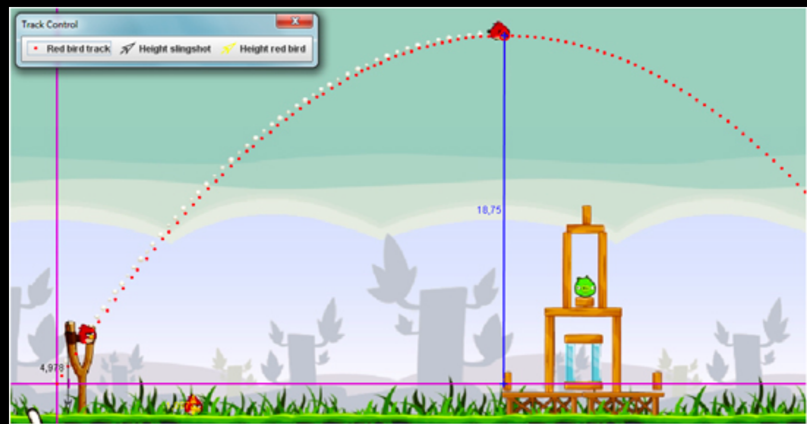
$$h = -16t^2 + vt + s$$

t- time
s – init height
v – init velocity
h - height



(model)

```python
import gym
import numpy as np
import random

env = gym.make("MountainCar-v0")
env.reset()

# print(env.observation_space.high)
# print(env.observation_space.low)
# print(env.action_space.n)

DISCRETE_OS_SIZE = [20] * len(env.observation_space.high)
discrete_os_win_size = (env.observation_space.high-env.observation_space.low) / DISCRETE_OS_SIZE

# print(discrete_os_win_size)

q_table = np.random.uniform(low=-2,high=0, size=(DISCRETE_OS_SIZE + [env.action_space.n]))



done = False
actioninput = [0,1,2]
while not done:
    # action 0 - turn left
    # action 1 - do nothing
    # action 2 - turn right
    action = random.choice(actioninput)
    new_state, reward, done, _ = env.step(action)
    print(reward, new_state)
    env.render()

env.close()
```



Basic concepts in Optimization

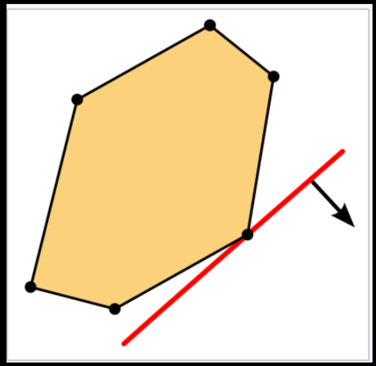
Linear Programming

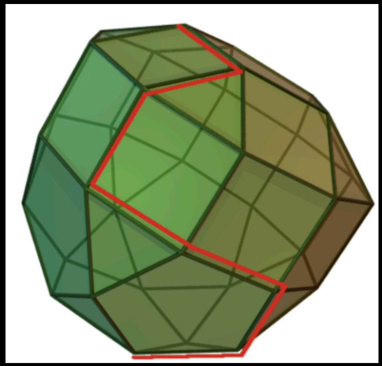
Simplex algorithm

Linear Programming problem:
- Decision variables
- Constraints
- Objective function

Linear Programming

(**LP**, also called **linear optimization**) is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships





- minimize or maximize a linear objective
- subject to linear equalities and inequalities

The optimization paradigm

1# Decision variables - sth under your control

– The work schedules of each employee
– The level of investments in a portfolio
– what subjects a student should take in each semester

2# Objective function (of the decision variables):

– minimize cost or ...
– maximize expected return or ...
– make the last semester as enjoyable as possible or ...

Source: MIT open course - https://ocw.mit.edu/courses/sloan-school-of-management/15-053-optimization-methods-in-management-science-spring-2013/lecture-notes/

The optimization paradigm

3# Constraints: restrictions on the decision variables:

– "Business rules"
- no worker can work more than 5 consecutive days
- There is at most 2% investment in any stock in the portfolio
- students must take a prerequisite of a subject before taking the subject

– "Physical laws"
- No worker can work a negative amount of time
- The amount of a goods in inventory at the end of period j is the amount of goods arriving during period j plus the amount of goods in inventory in period j-1 minus the amount of goods that are sold in the period.

Source: MIT open course - https://ocw.mit.edu/courses/sloan-school-of-management/15-053-optimization-methods-in-management-science-spring-2013/lecture-notes/

Generic optimization algorithm

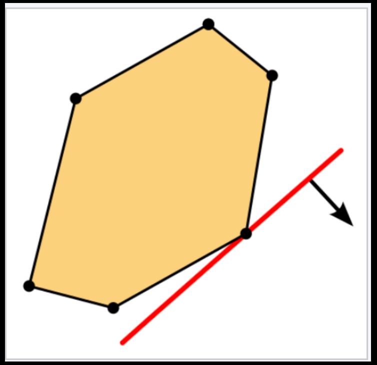
Let x be the vector of decision variables:
Suppose f, g1, g2, … , gm are functions

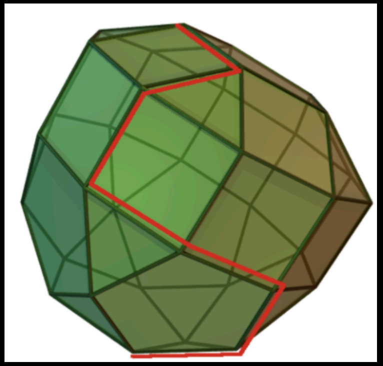
max f(x)
Maximize the objective

Subject to gi(x) ≥ bi

for each i = 1 to m
Satisfy the constraints

x ≥ 0
typically but not always the case.





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Putting this all together…
…we define 3 things

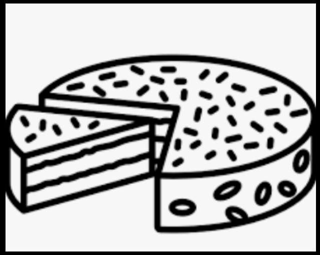
1# **Decision Variables** – we can manipulate them to achieve different results

2# **Constraints** – they put boundaries to our max or min function

3# **Objective function** – the goal we want to achieve

Example

- minimize or maximize a linear objective
- subject to linear equalities and inequalities



Max is in a pie eating contest that lasts 1 hour.
Each torte that he eats takes 2 minutes.
Each apple pie that he eats takes 3 minutes.
He receives 4 points for each torte and 5 points for each pie.

What should Max eat to get the most points?

Source: MIT open course - https://ocw.mit.edu/courses/sloan-school-of-management/15-053-optimization-methods-in-management-science-spring-2013/lecture-notes/

Step 1. Determine the decision variables

- Let x be the number of tortes eaten by Max.
- Let y be the number of pies eaten by Max.

Step 2. Determine the objective function

Maximize $z = 4x + 5y$ (objective function)

Step 3. Determine constraints

subject to $2x + 3y \leq 60$ (constraint)

$x \geq 0$; $y \geq 0$ (non-negativity constraints)

Simplex algorithm

Solution.

A feasible solution satisfies all of the constraints.

$x = 10$, $y = 10$ is feasible; $x = 10$, $y = 15$ is infeasible.

An optimal solution is the best feasible solution.

The optimal solution is $x = 30$, $y = 0$, $z = 120$

Source: MIT open course - https://ocw.mit.edu/courses/sloan-school-of-management/15-053-optimization-methods-in-management-science-spring-2013/lecture-notes/

Demo time

Thank you!