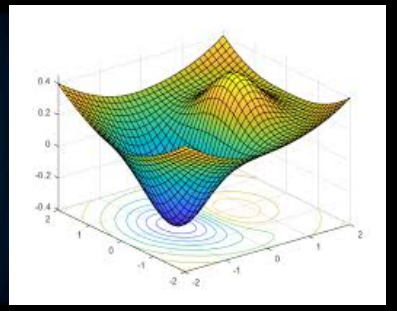
Build, Run and Manage your AI models

—

Nerav Doshi
Digital Technical Engagement Lead, IBM
Data and AI

Putting Data Science to Work for Business

- Machine Learning
- Mathematical Optimization
- Combining Machine Learning & Optimization
- Hands on Lab Machine Learning & Optimization



Poll 1: What is your background? Select all.

- ❑ Data science / machine learning
- ❑ Operations research
- ❑ Business intelligence and analytics
- ❑ Application development
- ❑ Lines of business
- ❑ AI / Cognitive research
- ❑ Dev Ops
- ❑ General IT

Data Science is

the practice of various scientific fields,

their algorithms, approaches and processes,

through the use of programming languages and software frameworks,

that aims to extract knowledge, insights and recommendations from data,

and deliver them to business users and consumers in consumable applications.

Optimization & Machine Learning is not new!

The birth of

Data Science

“Operations Research”

Mathematics to plan

military operations

The term

Machine Learning, 1959

Professor Arthur Samuel

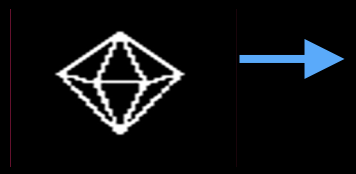
pioneer in the field of

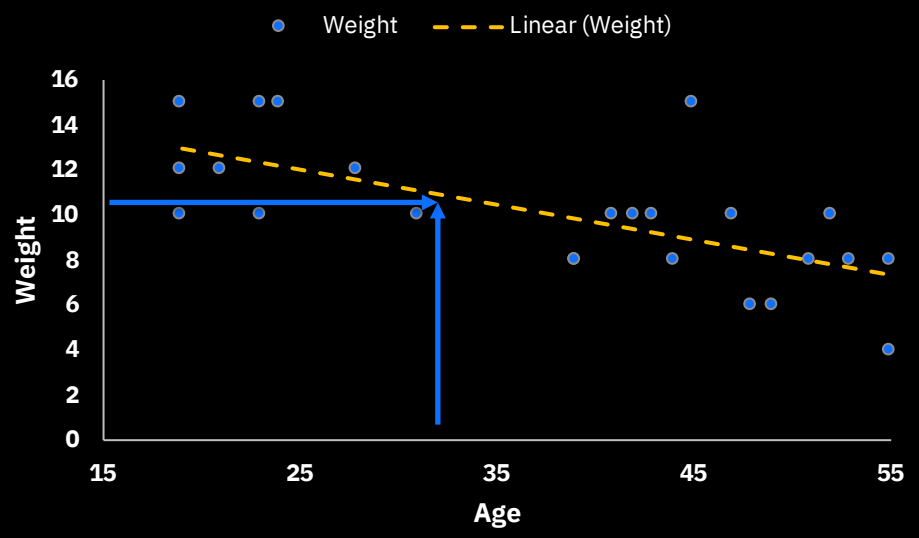
computer gaming and artificial intelligence.

https://www.youtube.com/watch?v=ILWbaWrjgU4

Machine Learning analyzes data and gives the computers the ability to **learn and predict** an **outcome**

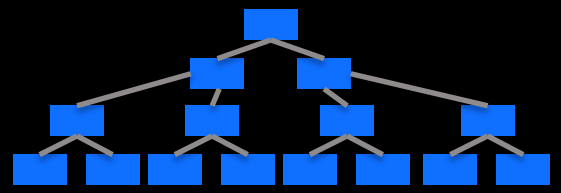
Sample data



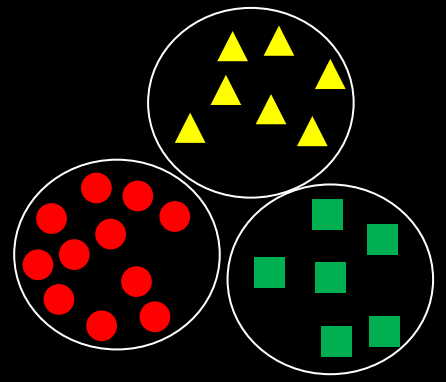


Prediction

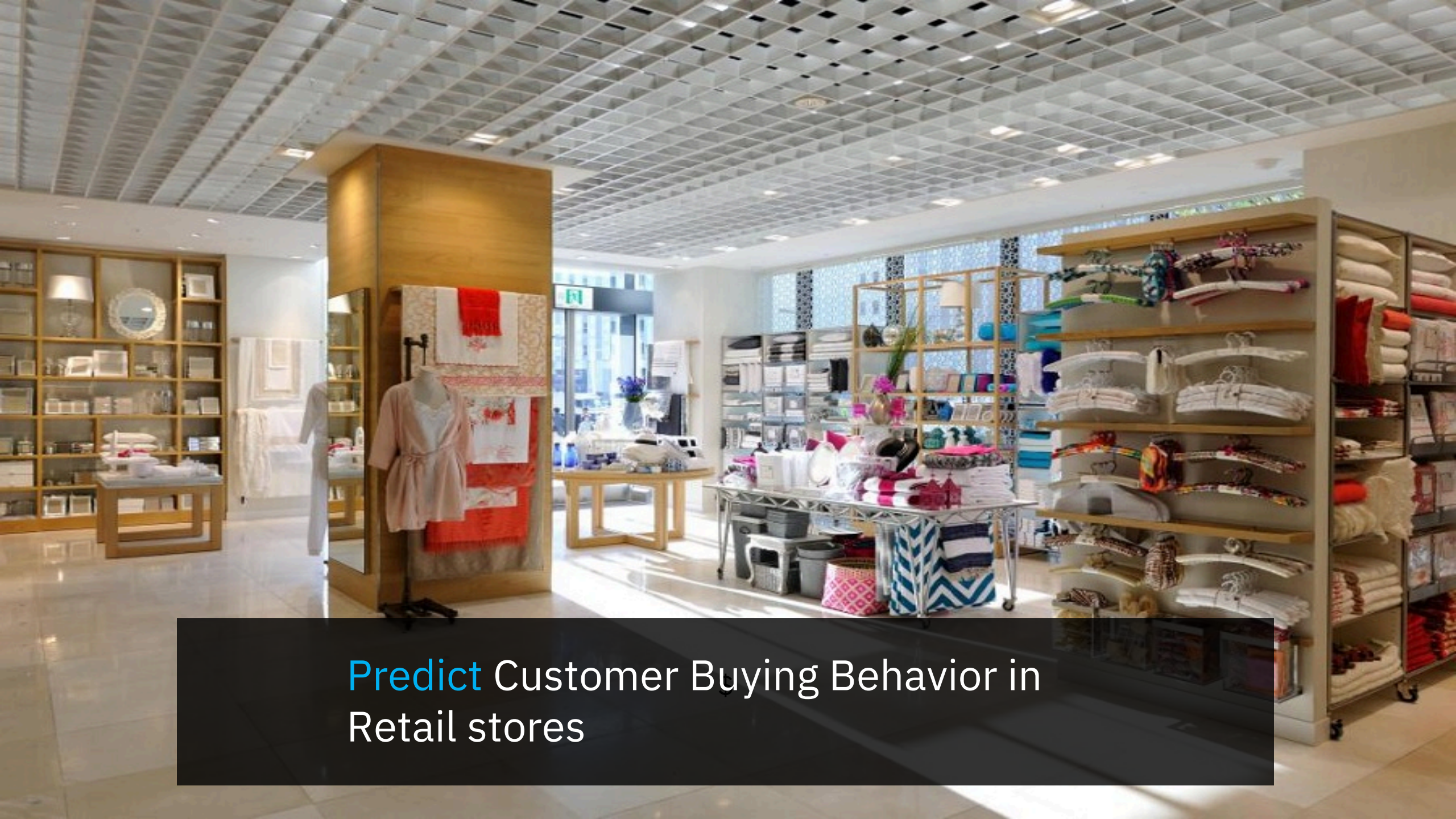
Classification



Clustering



Learners – Deep Learning , neural nets and reinforce learning



Predict Customer Buying Behavior in Retail stores

Predict Disruption in Supply Chain

Predict Equipment Failure

Banking

Predict fraudulent activities

Medical

Predict number of patents/cases

Government

Predict non-compliant behavior and tax evasion

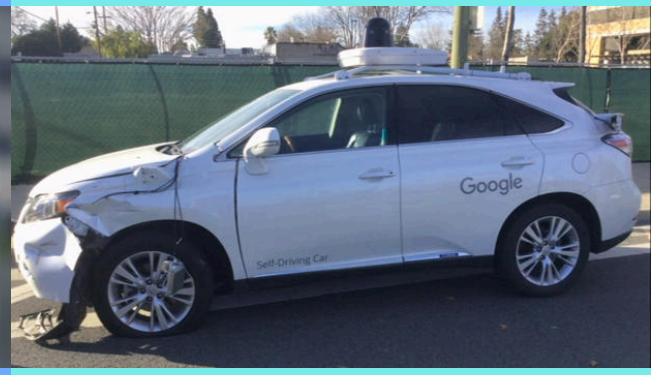
Challenges in Machine Learning

Probability of someone liking a particular movie is 80%

Netflix provides personalized recommendations

Waze provides a personalized driving experience

Uber delivers food that you like and is the right temperature



Self driving cars react to changing conditions

But ALL based on DATA and AI

Some Very successfully

Some not as successful

Challenges with Machine Learning Models

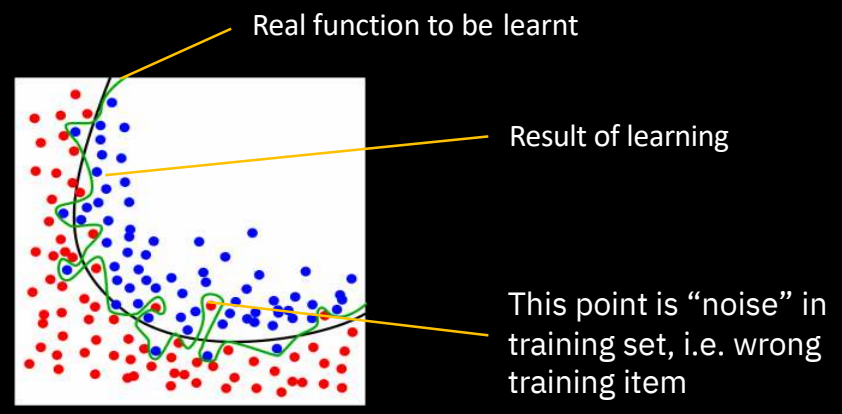
Trained model has a very poor score on some evaluation set

- Underfitting: not enough training?
- Overfitting: too much training and the two data sets do not correspond to the same "logic" ?

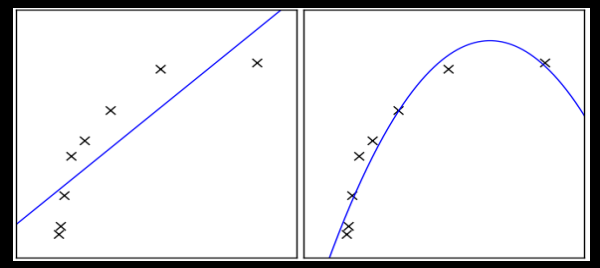
Application using deployed model (with good evaluation score) is unsuccessful

- Trained logic is wrong?

Overfitting: training takes into account "noise"/"errors" of training set



Underfitting: Too few points in training set.



Underfitted

Correctly Fitted

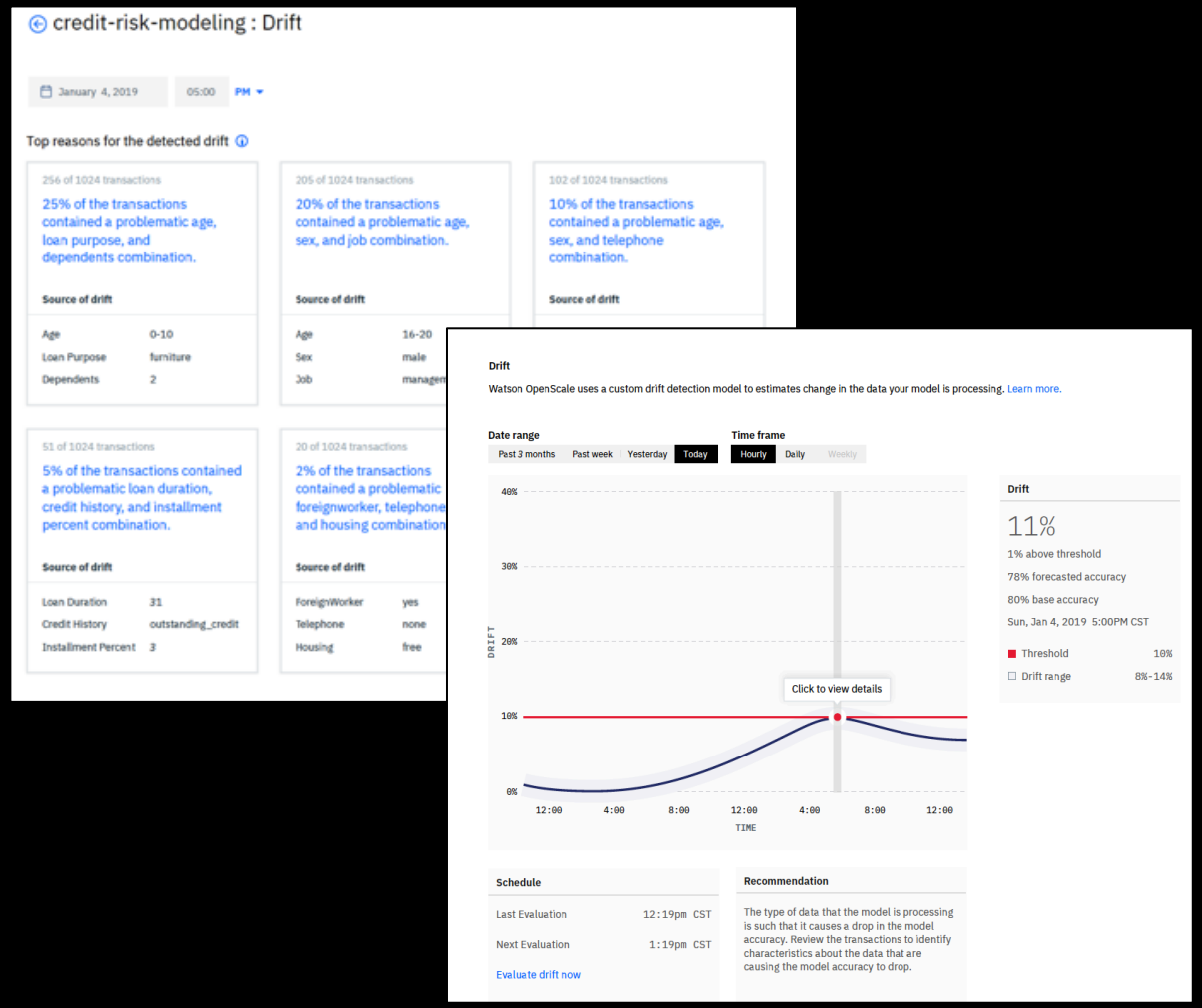
Challenges with Machine Learning

Ensuring Model Resilience

- Concept of Drift
- Provides actionable explanation of features causing drift

Models need to be retrained

Difficult to **track and measure** indicators of business success in production



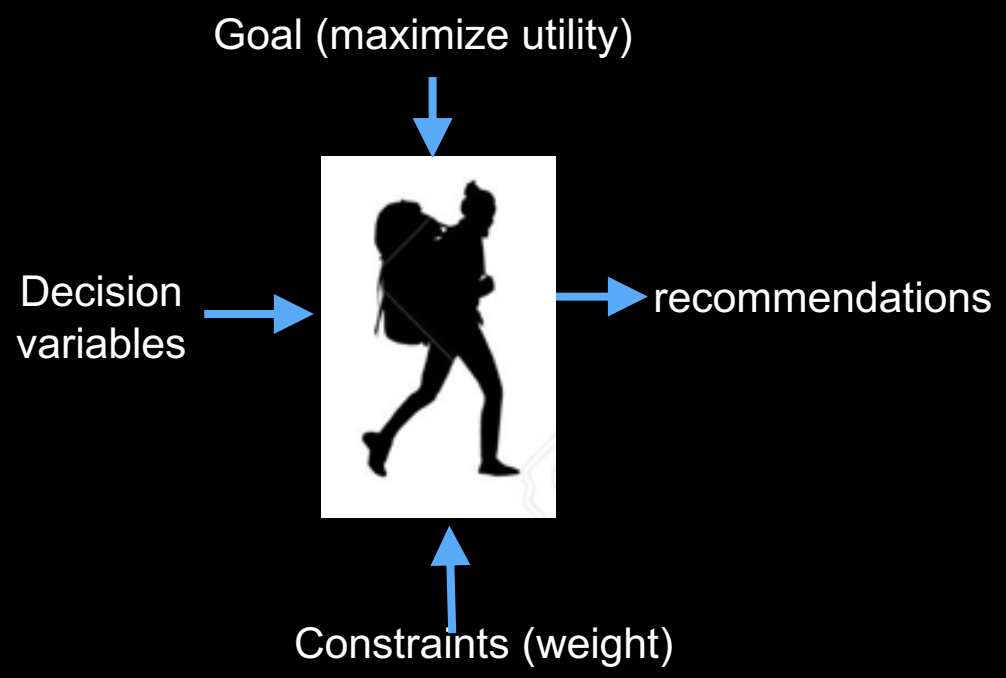
Prescriptive analytics

Prescribes the best course of action when making complex decisions.
The decisions need to be made around resources

Optimization techniques
Heuristics
Simulation
Rule based decisions
Stochastic Planning

Decision Optimization

Decision optimization is the application of one or more rigorous analytical techniques to a well- defined model to generate the absolute best decision from a multitude of possible alternatives in a rigorous, repeatable, and provable fashion.



Mathematical optimization
(Prescriptive Analytics)

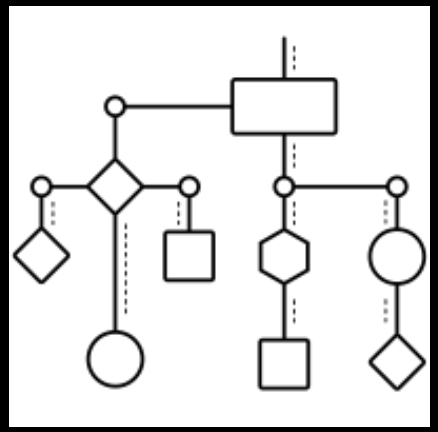
$$\min_{w \in R^n} f(w)$$
$$w \in W$$

1) Problem formulation:

- Objective function we want to optimize
- Decision Variables
- Constraints

2) Optimization algorithms:

- Given the mathematical formulation, how to find a solution to the problem



What is Prescriptive Analytics used for?

- Manage efficiency, utilization and allocation of limited resources
- Resources can be a number of things:

Resources	Choices to make
Capital	Invest, allocate
People	Hire, assign, schedule
Equipment	Acquire, schedule, locate
Facilities	Locate, size, schedule, maintain
Vehicles	Acquire, route, schedule, deliver, maintain
Material/Product	Acquire, allocate, produce, deliver, maintain

- Keywords to look out for:
  - Minimize and maximize
  - How many, how much, which, when, where
  - Decide, choose, plan, schedule, assign, route, source, maintain, locate, trade-off

Since 1936, Optimization and mathematical has changed the world

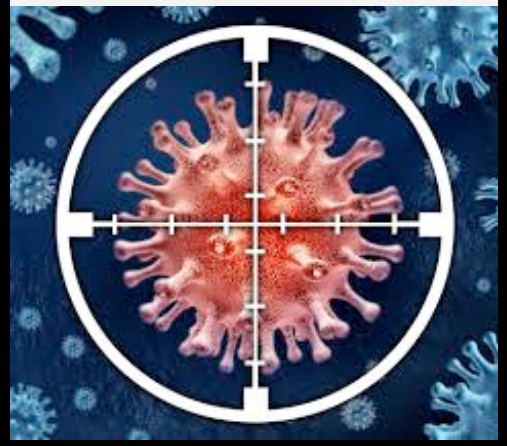
37 years, 37 Edelman winners, upwards of $200 billion cumulative ROI

Reduced HIV infection rates

New Haven Health Department – Edelman winner 1992

More effective cancer treatment

Memorial Sloan-Kettering Cancer Center – Edelman winner 2007



Protection against floods

Dutch Delta program – Edelman winner 2013

Help eradicate Polio in Africa

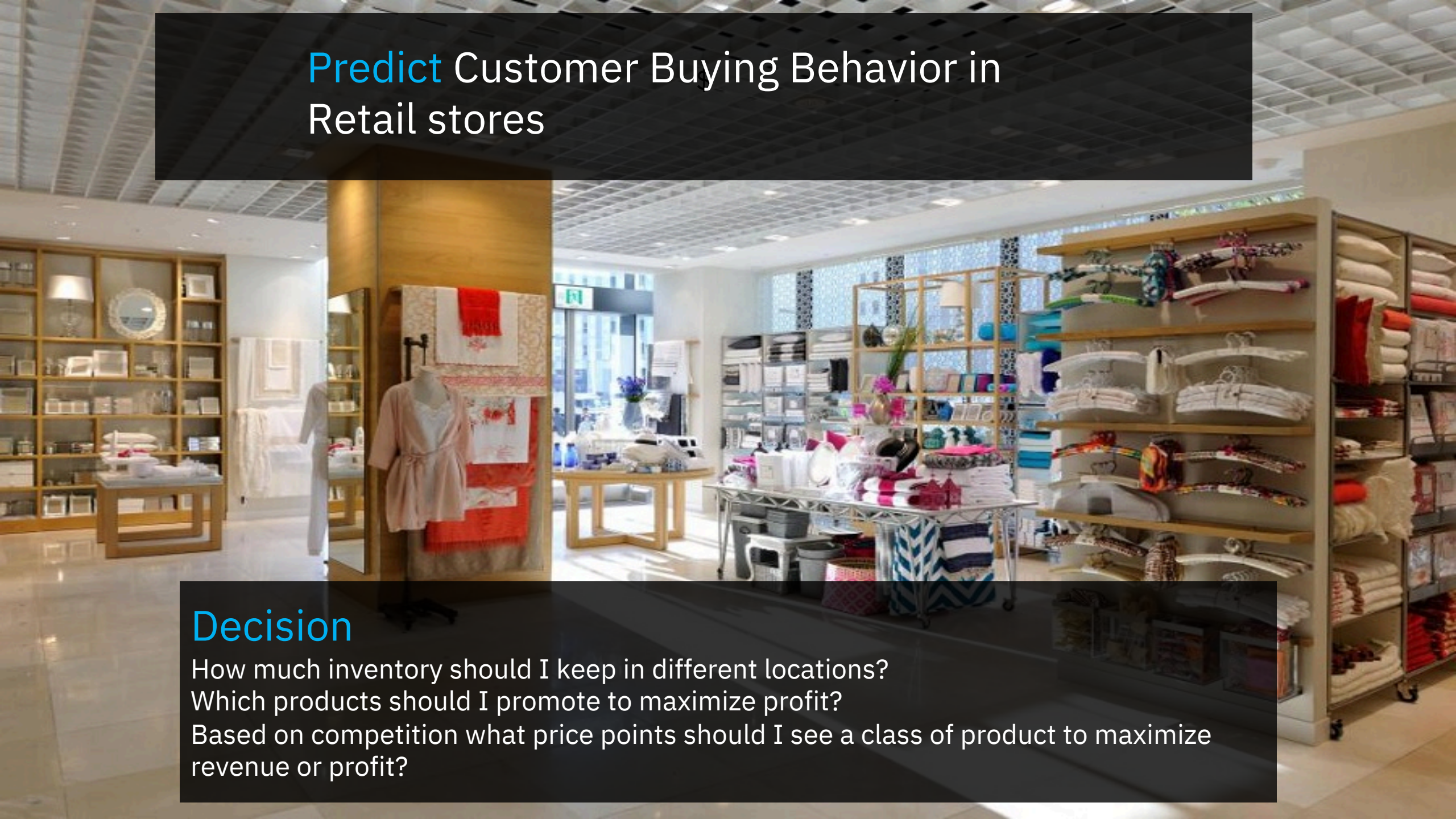
US Center for Disease Control – Edelman winner 2014

Reduce carbon emissions

UPS – Edelman winner 2016

Source: Edelman Finalists, http://www.informs.org or http://www.scienceofbetter.org

Predict Customer Buying Behavior in Retail stores



Decision

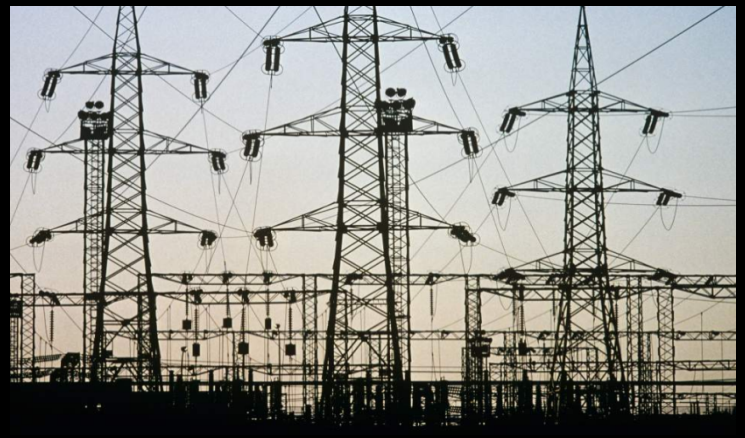
How much inventory should I keep in different locations?
Which products should I promote to maximize profit?
Based on competition what price points should I see a class of product to maximize revenue or profit?

Predict Disruption in Supply Chain

Decision

What should I produce in my various production facilities?
Is the inventory being deployed in cost effective way; delivery from store vs distribution center?
How can I reduce my total landed cost?

Predict Equipment Failure



Decision

Optimize maintenance schedule, who do we assign based on skills, replacement part availability and cost

Minimize production/machine downtime

Banking

Predict fraudulent activities

Decision to assign security resources to follow-up with customers and take corrective action

Medical

Predict number of patents/cases

Decision - Which worker should work in each shift?

Government

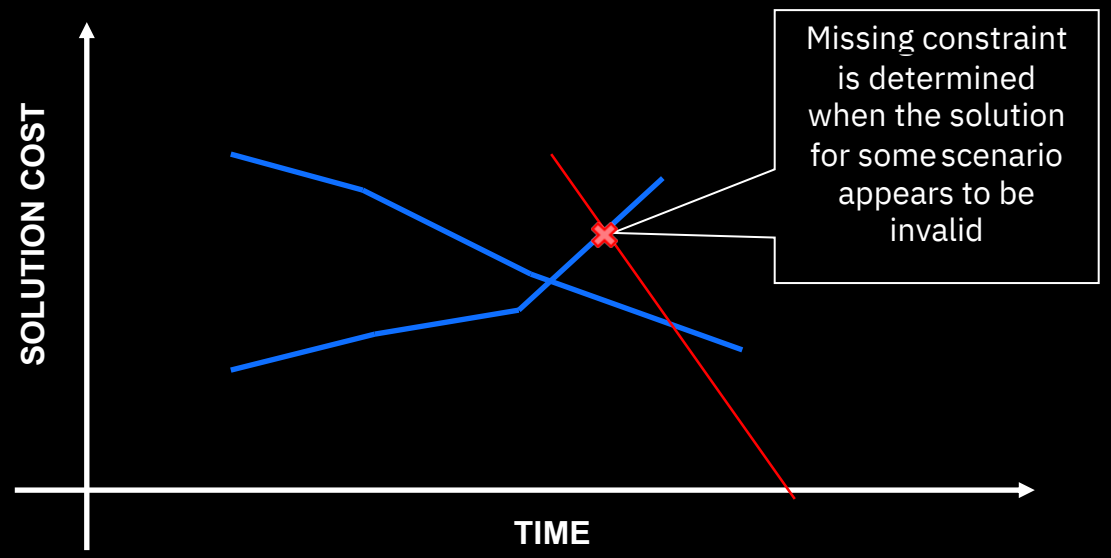
Predict non-compliant behavior and tax evasion

Decision to look at cases where they would maximize tax recoupment

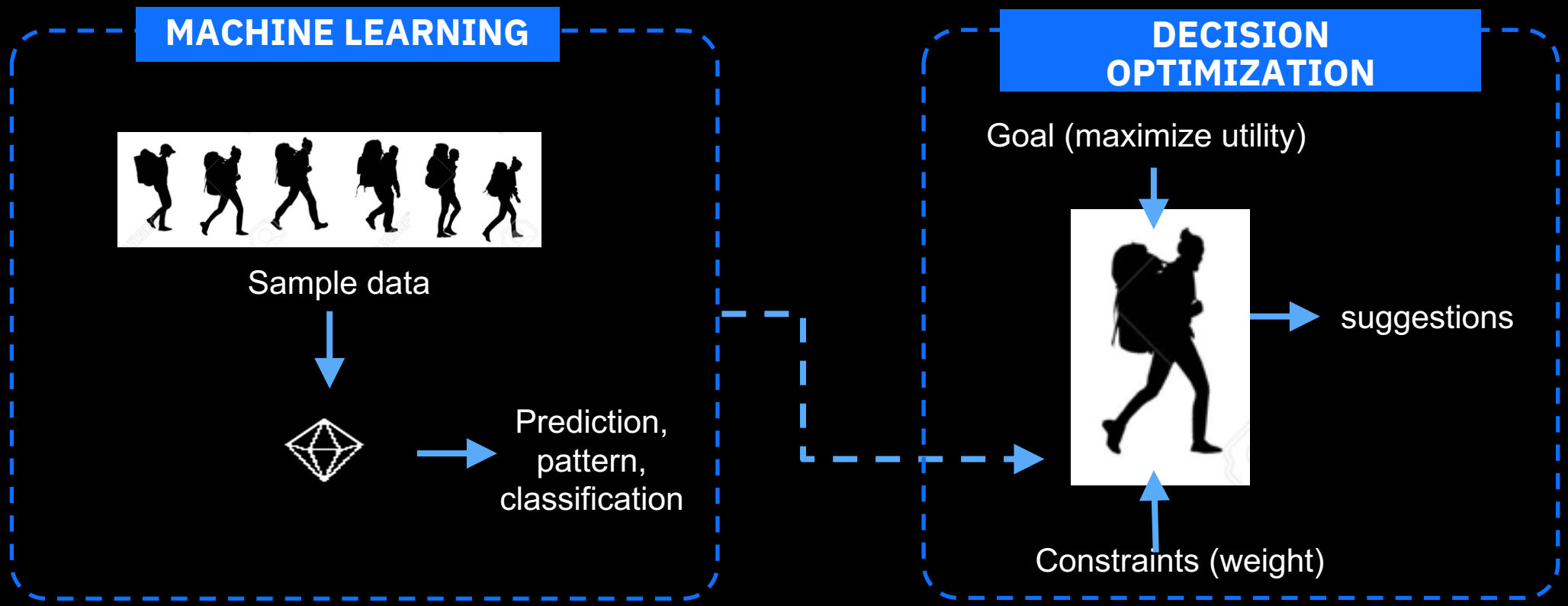
Challenges with Optimization Problem

DO models are programmed and solutions correspond to problem formulation:

- Garbage in garbage out
- Some solutions are wrong with respect to the business rules
- Modeling error might be due to some constraint is missing or are too strong in the model that it takes a lot of time due to conflicting constraints
- It may appear some solution is better than the proven optimal one according to model.



Machine Learning for Predictive vs. Optimization for Prescriptive



- Basic (supervised): you **know the answer** and you **train the machine how to find it**
- More advanced – unsupervised, reinforcement, & deep learning

- You **don't know the answer**, and you **provide the machine the logic on what is a good and a bad solution**
- More advanced – robust/stochastic/…

Difference between ML and Optimization

Fitting VS Approximating

There is a huge difference between Optimization and ML

In optimization we solve:

$$\min_{w} \sum_{p=1}^{P_{train}} \left(\phi(w; x_p) - y_p\right)^2$$

Data fitting

What we would like to solve in ML , instead, is:

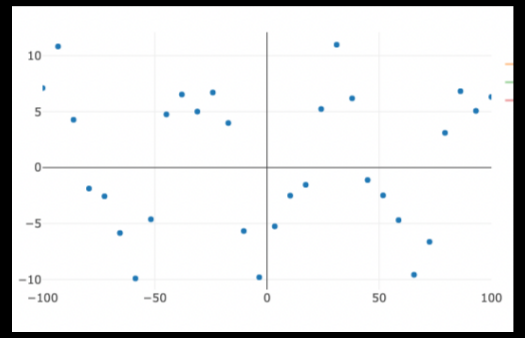
$$\min_{w} \sum_{p=1}^{P_{test}} \left(\phi(w; x_p) - y_p\right)^2$$

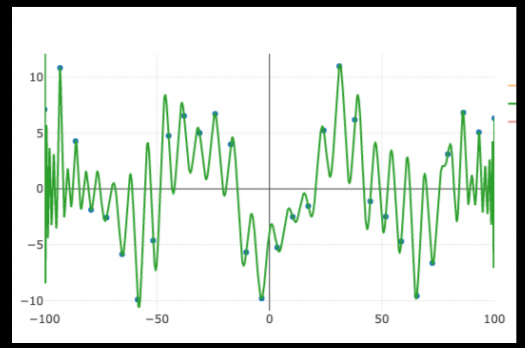
Function approximation

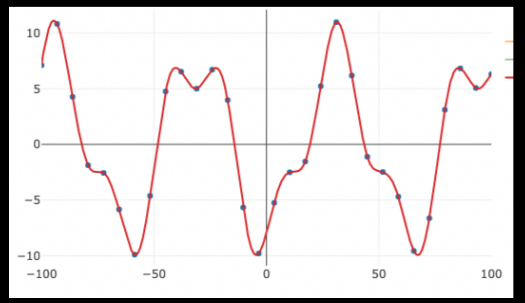
Where P_{test} are never seen before instances

Practical solutions:

Regularization, Crossvalidation, Early Stopping

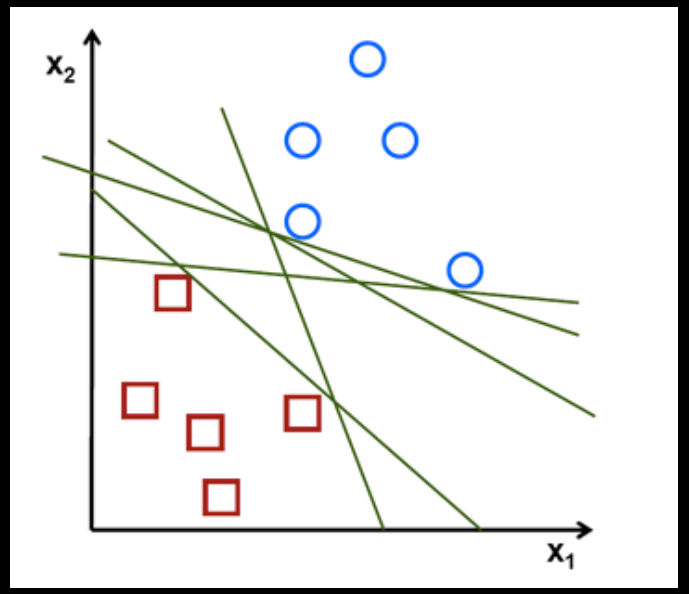




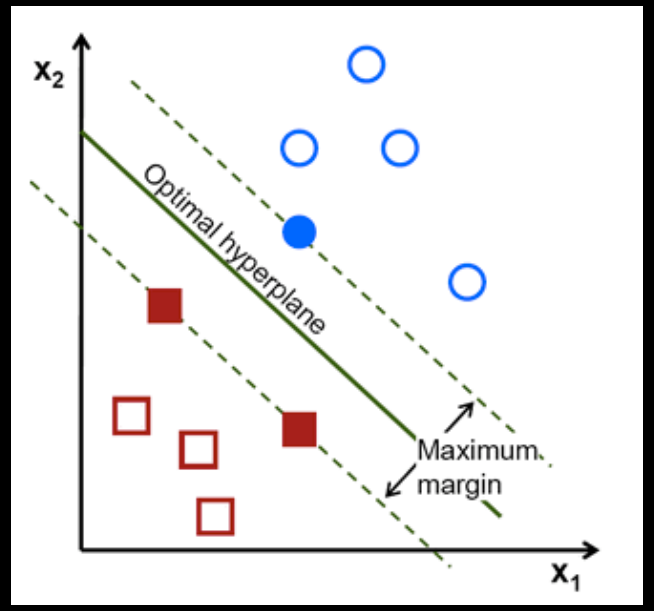


Optimization innovations can help Machine Learning algorithm

E.g. Support Vector Machines (SVM): For a set of points which belong to two classes, find a separating straight line [1]



The optimal separating hyperplane *maximizes* the margin of the training data



OR innovations speed up SVM performance

Previously unsolvable classification problems are now solvable in seconds [2,3]

Many more examples … [3]

Sources:

1. http://docs.opencv.org/2.4/doc/tutorials/ml/introduction_to_svm/introduction_to_svm.html
2. "On Handling Indicator Constraints in Mixed Integer Programming," P. Belotti, P. Bonami, M. Fischetti, A. Lodi, M. Monaci, A. Nogales-Gomez, D. Salvagnin, Computational Optimization and Applications, 1-22, 2016
3. https://cpaior2017.dei.unipd.it/slides/Lodi.pdf

Predictive vs Prescriptive: if you want to predict something, it's likely because you want to decide (prescribe) something

	Marketing	Sales	Finance	IT	Operations	HR
Predict	Campaign ROI	Revenue per territory	Rates of return	Help desk workload	Demand	Employee retention
Prescribe (optimize)	Plan marketing campaign	Assign territories to sales team	Optimize investment portfolio	Assign helpdesk staff	Plan sales & operations	Plan compensation & training

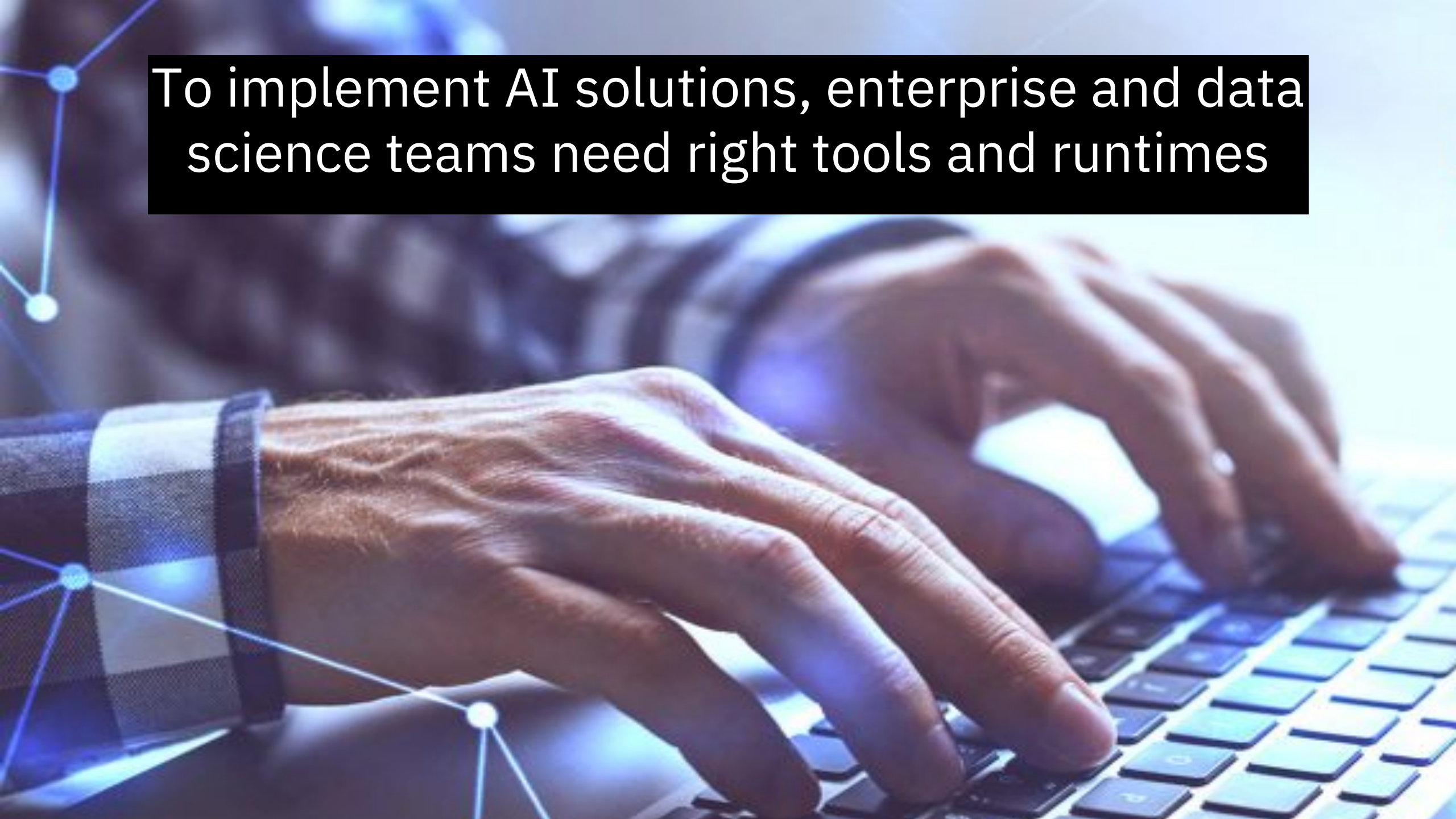
Important: many prescriptive problems don't involve a prediction

Poll 2: What is your background? Select all.

What are some use cases discussed where one can apply Machine Learning and Decision Optimization

- ❑ Predictive Maintenance
- ❑ Retail promotion planning
- ❑ Supply Demand Balance
- ❑ Workforce Scheduling
- ❑ All of the above

To implement AI solutions, enterprise and data science teams need right tools and runtimes



Demonstration

https://github.com/nmdoshi/HandsOnLabDOWS

Try Watson Studio For Free

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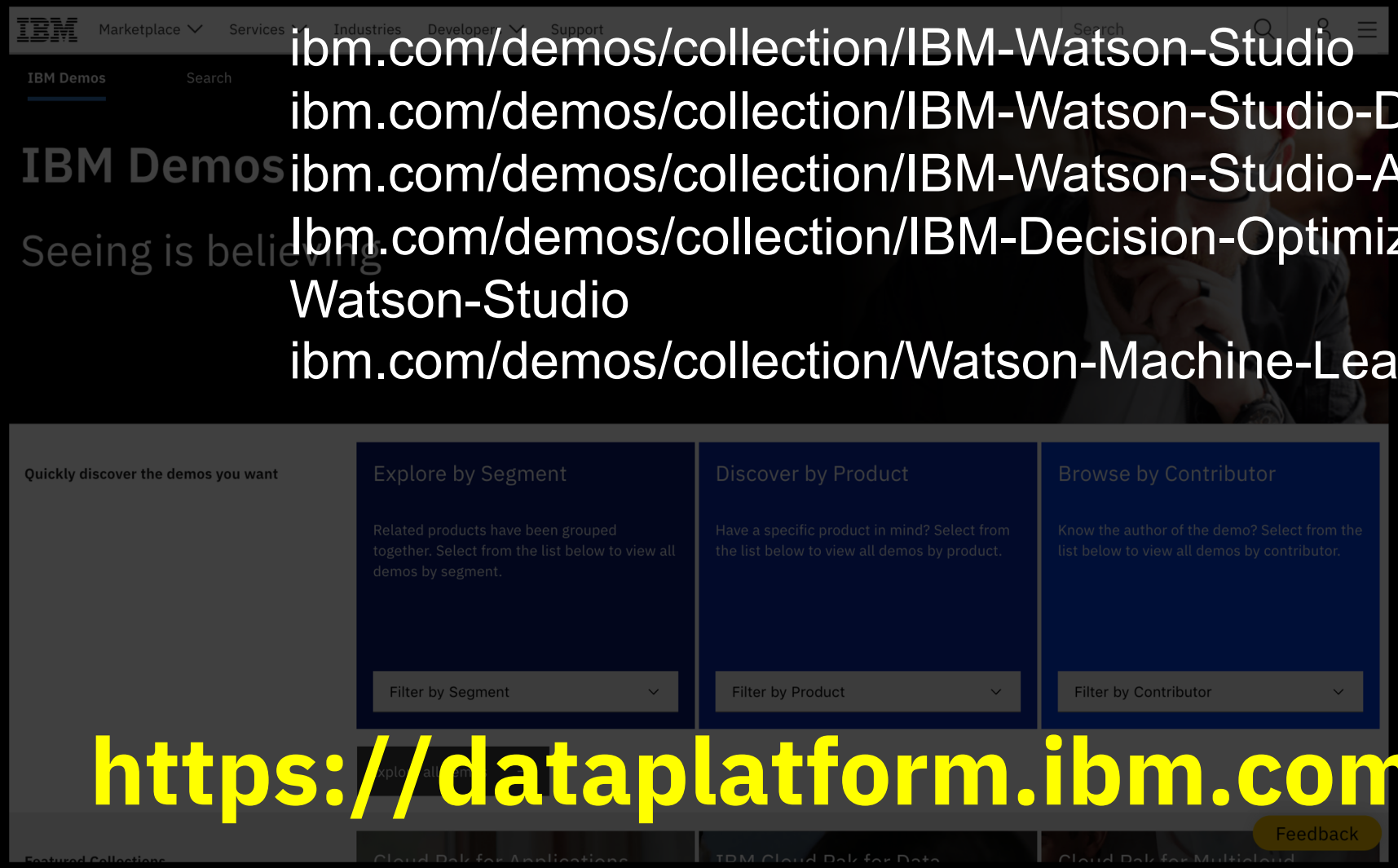


https://dataplatform.ibm.com

Questions & Answers

Watson AI Technology Series

IBM **Developer**

Online Event

Build, Run and Manage your AI Models - Part I

Using prediction and optimization to build apps

Friday, April 10, 8:30am - 10:00am PT
Online

IBM **Developer**

Online Event

Build, Run and Manage your AI Models - Part II

Manage, measure and explain AI models

Friday, May 1, 8:30am - 10:00am PT
Online

IBM **Developer**

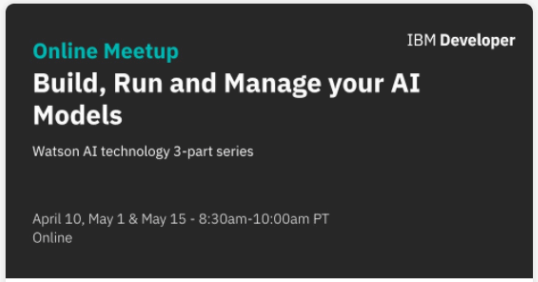
Online Event

Build, Run and Manage your AI Models - Part III

AutoAI deep dive

Friday, May 15, 8:30am - 10:00am PT
Online

https://www.meetup.com/IBM-Developer-SF-Bay-Area-Meetup
https://www.crowdcast.io/ibmdeveloper



Watson AI technology 3-part series: Build, Run and Manage your AI Models

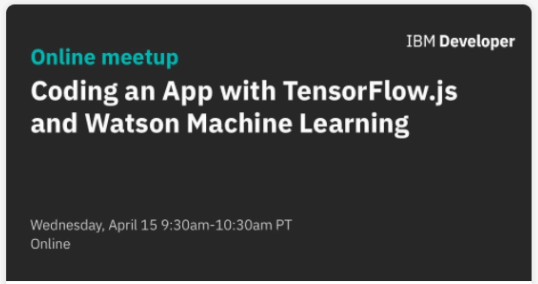
Apr 10, 2020 8:30 am

Application Deployment Options for OpenShift 4 on IBM Cloud

Apr 13, 2020 9:30 am

AI & ML Online Developer Summit

Apr 14, 2020 8:45 am

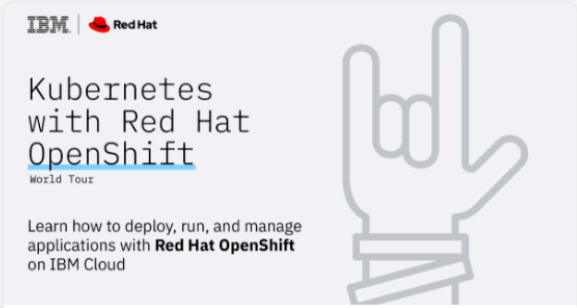


Coding an App with TensorFlow.js and Watson Machine Learning

Apr 15, 2020 9:30 am

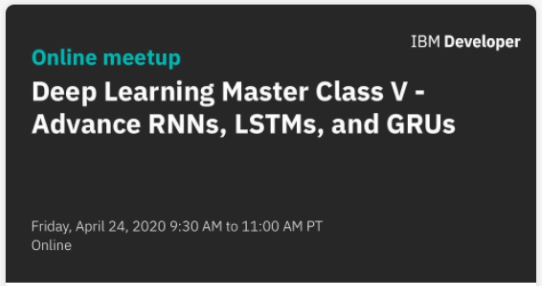
How to Quickly Build Solutions that Fight Back

Apr 20, 2020 9:30 am



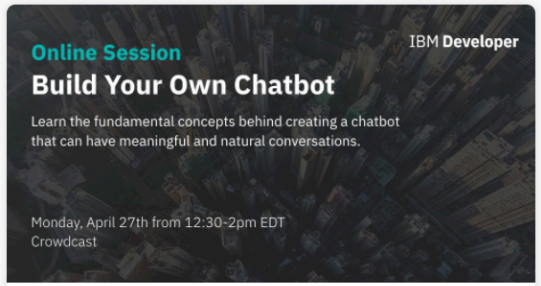
Kubernetes with Red Hat OpenShift Workshop

Apr 21, 2020 10:00 am



Deep Learning Master Class V - Advance RNNs, LSTMs, and GRUs

Apr 24, 2020 9:30 am



Build Your Own Chatbot

Apr 27, 2020 9:30 am

20 CALL FOR 20 CODE®
Global Challenge

Participants:
Register for the challenge, and start building

Sponsors:
Show your full support with a sponsorship

COVID-19 Reference Materials:
We have the tools. You have the talent.

More information:
Find more details at ibm.biz/callforcode

Build solutions that fight back.

Join a **movement** of:

- **210,000** developers, data scientists & problem solvers
- **165+** nations
- **8,000+** applications built in the prior 2 years

Help seize & reduce the impacts of the COVID-19 pandemic by addressing:

- **Crisis Communication**
- **Remote Education**
- **Community Cooperation**

Help halt & reverse climate change by addressing:

- **Water sustainability**
- **Energy sustainability**
- **Disaster resiliency**

Have the chance to be **awarded:**

- **$200,000** USD
- Open Source support from **The Linux Foundation**
- Meetings with **mentors** & potential **investors**
- **Solution implementation** support through **Code and Response™**

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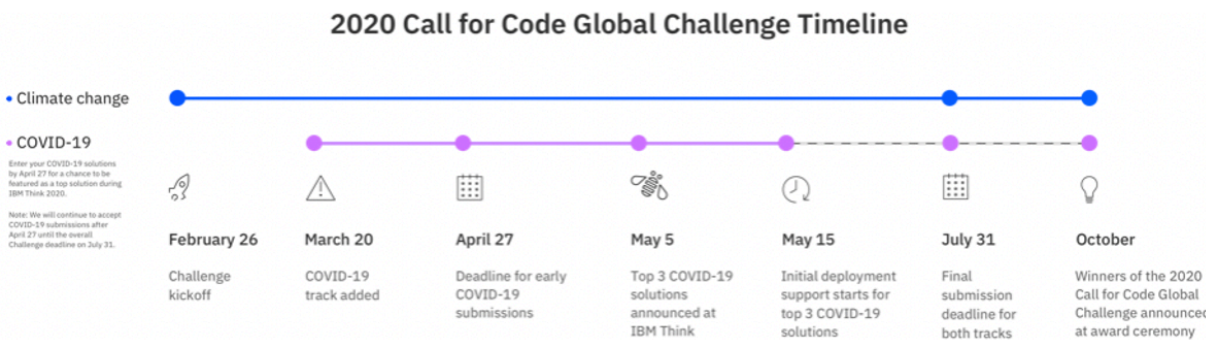

APRIL 14, 2020 | 8:45AM PT

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AI & ML Online Developer Summit

IBM Developer

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